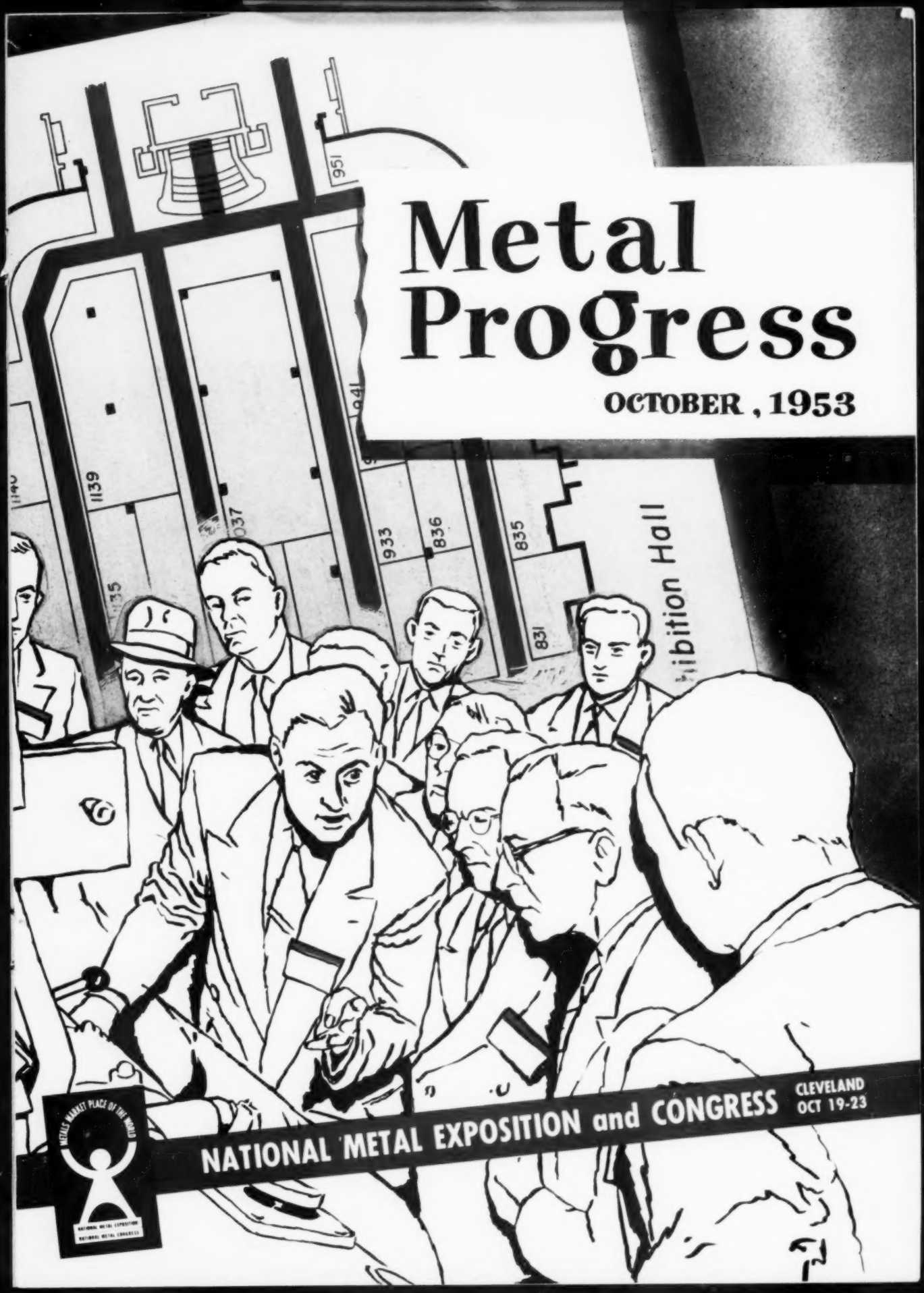
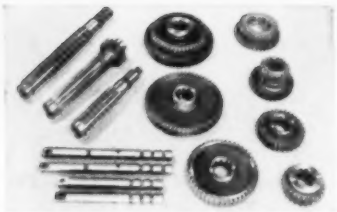
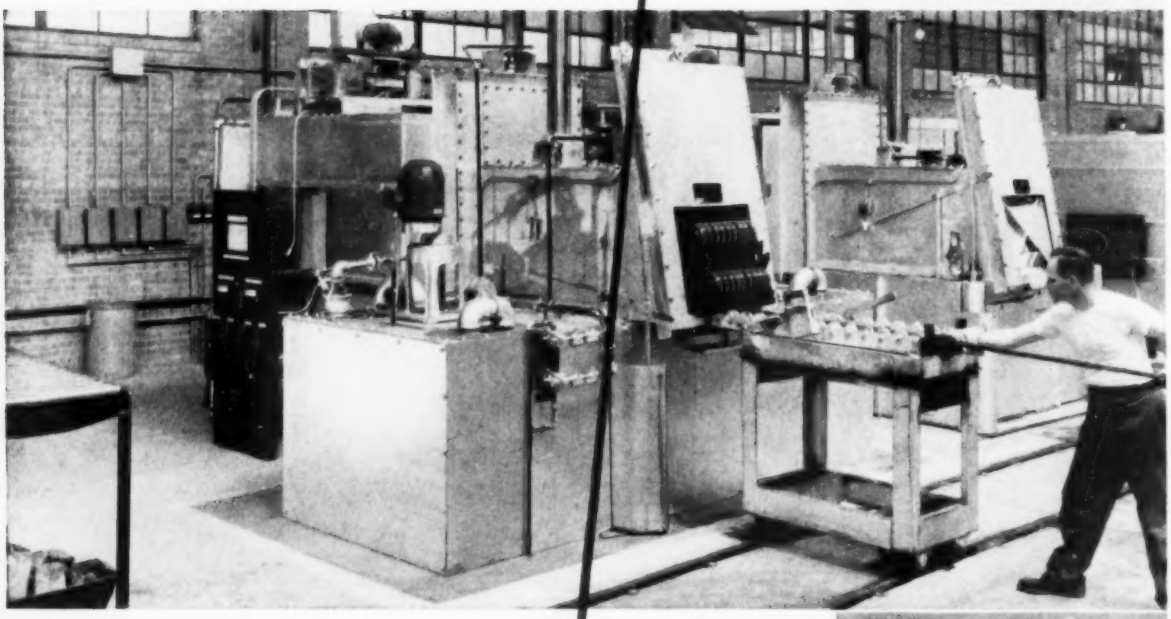

Metal
Progress
OCTOBER, 1953
NATIONAL METAL EXPOSITION and CONGRESS
CLEVELAND
OCT 19-23

Surface Allcase Furnaces

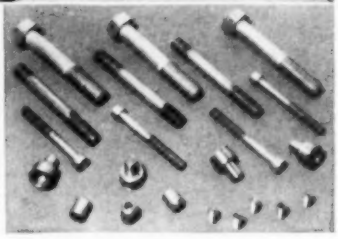




put production way up



and costs way down



A consistently rising demand for the Allcase furnace has necessitated production line manufacture. This is the best proof that these batch type radiant tube controlled atmosphere furnaces really have the capacity, versatility, and operating economy to make a small investment pay off quickly. They provide for gas carburizing, marquenching, clean hardening, dry cyaniding, carbon restoration, homogeneous carburizing, and clean annealing. One man can handle several Allcases . . . Gross heating rates are: Standard size: 500 lbs/hr.—Heavy-duty: 1600 lbs/hr. Write for Literature Group H53-8, or better still . . .

. . . SEE ALLCASE IN ACTION DURING THE METAL SHOW IN CLEVELAND: Surface Booth No. 321.

Surface
HEAT TREATING EQUIPMENT

SURFACE COMBUSTION CORPORATION • TOLEDO 1, OHIO

ALSO MAKERS OF

Kathabar HUMIDITY CONDITIONING *Janitrol* AUTOMATIC SPACE HEATING

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The red carpet rolls down the aisles of the floor plan for the 1953 Metal Show in Cleveland.

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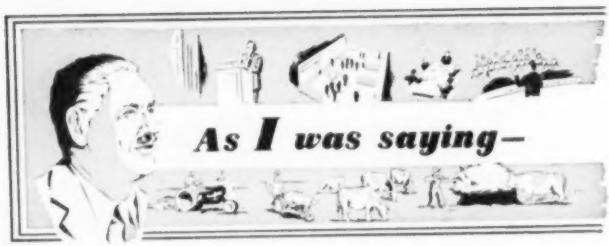
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• **See** *Bill's Column on the other side* ➡



THE BIG METAL SHOW and the annual convention of your Society are just about ready to burst out all over Cleveland. This year there seems to be just that little something which makes them unusual and which portends one of the top events of A.S.M.'s 35-year history.

Speaking of 35 years causes me to recall the first convention and exposition of your young Society. It was held in Chicago in September of 1919 with the Morrison Hotel as headquarters and the Seventh Regiment Armory housing the first exposition of its kind ever held in the world.

Just to refresh my memory, I looked over the program and noted that papers were presented by a number of members who are still active in the Society: Roy McKenna of Vanadium-Alloys, C. U. Scott of C. U. Scott & Son, G. Walter Esau of E. F. Houghton, Harry Knowlton of International Harvester, Harry Harris of General Alloys, Carl Hewitt of Fafnir Bearings, George Tall, Jr., of Leeds and Northrup, Arthur W. F. Greene of General Motors, Colonel A. E. White of University of Michigan, and Claud Gordon. You will be able to see and greet these outstanding authorities, and many others, at the Congress in Cleveland.

The second Congress was held in Philadelphia in 1920. It not only had a wider technical program but also marked the occasion when the Detroit and Chicago branches of the metal treating industry combined to form the present organization.

Every once in a while, you hear someone remark, "In the olden days it was just a heat treat show, and now it has become large and is a metalworking show." Everyone admits that is true, but all we need to do to balance this question of growth in size and functions is to realize that the Society itself has grown in size and functions.

Let's consider for a moment the makeup of the membership. We find that while 100% of the members are in the metalworking industry, only 30.99% are in metallurgy and heat treatment. The membership of the Society is classified as follows: corporate officials, 16.55%; production, 15.00%; engineering and design, 16.75%; metallurgists, 30.99%; sales, 0.56%; purchasing, 10.79%; education and others, 9.36%.

So it is only natural that with the growth of the Society in functions of the members, as well as in numbers, and with the increasing importance of metallurgical problems in industry, the Show has become large and varied; it appeals to a great many divisions of the industry and the membership.

There is no need to worry, though, about the Show getting any larger because under present conditions that is impossible. It now fills to capacity the three largest convention halls in America (Chicago, Cleveland, and Philadelphia), with many firms waiting for admission on the chance of a cancellation.

We are all very proud indeed of the fine technical programs being presented by the American Welding Society, the American Institute of Mining and Metallurgical Engineers, and the Society for Nondestructive Testing at the Congress.

I am sincerely in hopes that as many of you as can will avail yourselves of the opportunity to come to Cleveland, not only to attend the seminar on Saturday and Sunday, but also the exposition and other technical programs opening on the 19th.

It is a great educational feast that will be of immense benefit to you; it is something you will enjoy, and it will leave with you a lasting memory.

I'll be seeing you.

Cordially yours,

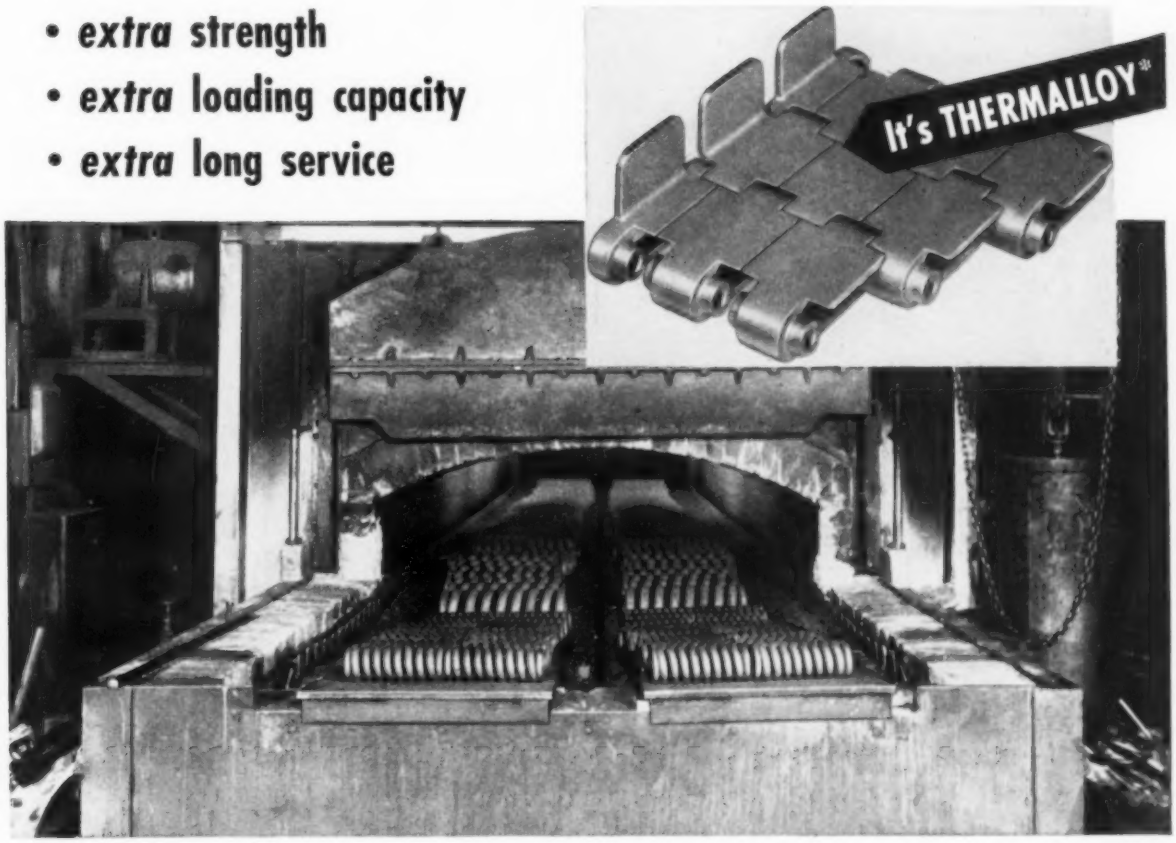
Bill

W. H. EISENMAN, *Secretary*
AMERICAN SOCIETY FOR METALS

NEW CONVEYOR DESIGN

offers extra heat-treat advantages . . .

- *extra* strength
- *extra* loading capacity
- *extra* long service



This new conveyor belt† was designed to carry loads not possible with conventional style belts. It does not replace conventional cast belts, but serves to widen the field to applications involving extreme temperature and loading conditions formerly unattainable with ordinary belts.

The new Thermalloy staggered-link, conveyor design shown above offers you these features:

1. Elimination of crank-shafting.
2. A free-floating link which can adjust itself to meet localized stresses.
3. The substitution of strong, wear-resistant, cast-in pins for the weaker wrought pins.

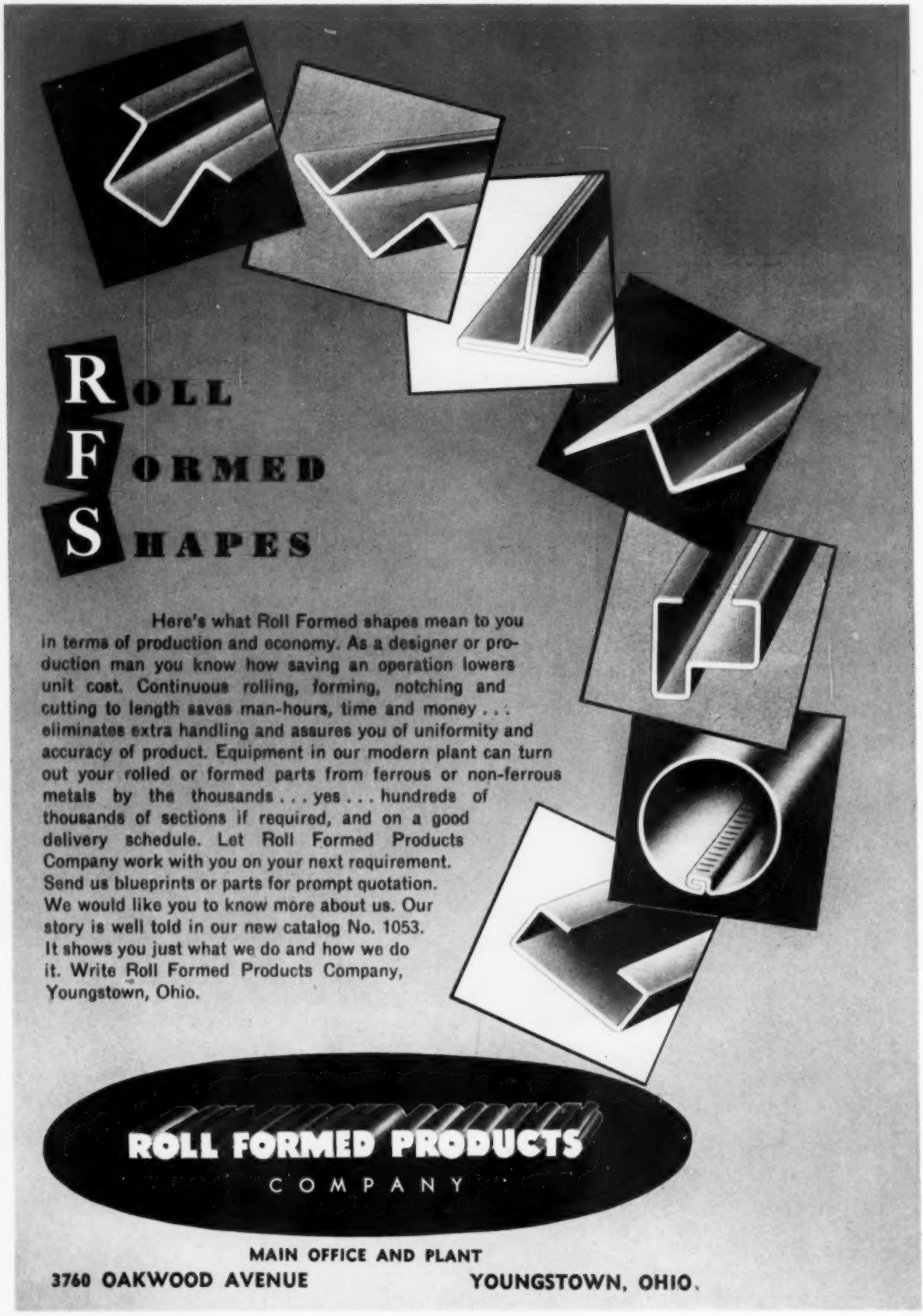
For complete information on this new Thermalloy conveyor belt, standard belts or other furnace parts, contact your nearest Electro-Alloys representative. Or write Electro-Alloys Division, 4002 Taylor Street, Elyria, Ohio.

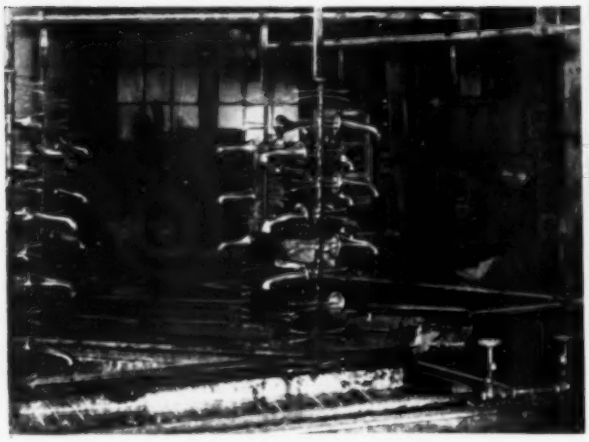
*Reg. U.S. Pat Off.

†Pat. Applied For

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ELECTRO-ALLOYS DIVISION
ELYRIA, OHIO


ROLL
FORMED
SHAPES
Here's what Roll Formed shapes mean to you in terms of production and economy. As a designer or production man you know how saving an operation lowers unit cost. Continuous rolling, forming, notching and cutting to length saves man-hours, time and money . . . eliminates extra handling and assures you of uniformity and accuracy of product. Equipment in our modern plant can turn out your rolled or formed parts from ferrous or non-ferrous metals by the thousands . . . yes . . . hundreds of thousands of sections if required, and on a good delivery schedule. Let Roll Formed Products Company work with you on your next requirement. Send us blueprints or parts for prompt quotation. We would like you to know more about us. Our story is well told in our new catalog No. 1053. It shows you just what we do and how we do it. Write Roll Formed Products Company, Youngstown, Ohio.
ROLL FORMED PRODUCTS
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3760 OAKWOOD AVENUE
YOUNGSTOWN, OHIO.



Electromax for plating-tank control at Barnes Manufacturing Co. (plumbing fixtures) saves its cost in 6 months in reduced maintenance. Electromax resists humidity & acid mist.



The Sterling China Co. says "Our two Electromaxes do a perfect job at no expense; no maintenance; no attention from supervisors". Electromax resists dust & vibration.

No-maintenance Controller?

WELL, ALMOST . . .

● For years at a time, your instrument maintenance men may never even see the inside of your Electromax Temperature Controllers.

And when they do look into one, they find only five items that could ever need replacing—two 120-volt light bulbs, two ordinary radio tubes and a relay. All five of these expendable elements could be replaced in five minutes.

Fine engineering, however, greatly reduces the chance of even that much maintenance. Design requires the two radio tubes to operate at only 10% of rating. The relay (the only moving part in the whole instrument) is a hermetically-sealed, plug-in type. There's no dry cell, no standard cell, no ink, no chart, nothing to lubricate.

With its small size, low price, excellent accuracy and really remarkable simplicity, you'll find many uses for Electromax, at temperatures to 1000 F. You can get full information from the L&N office nearest you, or from 4927 Stenton Ave., Philadelphia 44, Pa.

LEEDS NORTHRUP

instruments · automatic controls · furnaces

Jrl ad ND46(13)

Metal Progress is copyrighted, 1953, by American Society for Metals and is published at 304 N. Wesley Ave., Mt. Morris, Ill. Issued monthly; subscriptions $7.50 a year. Application pending for transfer of entry from Cleveland, Ohio to Mt. Morris, Illinois.

Which of these BASIC MATERIALS will solve *your* processing problems?

Norton electric furnace products are engineered and prescribed to meet many manufacturing needs

Backed by over 50 years of experience in electrochemical refining, Norton brings you basic materials whose purity and properties are carefully controlled and consistently duplicated.

These Norton electric furnace products differ greatly in composition and characteristics. They are the source of the many Norton *engineered prescriptions* which have proved of immense practical value in widely varying processes.

Moreover, each of them has possibilities for use which are still undiscovered. It will pay you, therefore, to read the following descriptions very carefully. Even this partial list may contain the exact combinations of properties *you* need.

ALUMINUM OXIDE (ALUNDUM®)

Norton is the world's largest producer of this basic material — fused alumina. *Characteristics:* high melting point, about 3700°F; specific gravity, 3.95; good chemical stability, neutral to most chemical reagents; extreme hardness of 2000 Knoop, with great toughness; reasonably high thermal conductivity, 2½ times that of fire clay; high dielectric strength. *Uses:* heavy refractory furnace shapes; pure oxide and sintered refractories; radio tube insulation; porous media for filtration and diffusion; catalyst carriers and fluid catalysts; heat exchange pebbles; wear-resistant parts; laboratory ware.

SILICON CARBIDE (CRYSTOLON®)

Silicon carbide is produced by Norton in large tonnages. *Characteristics:* high melting point, disassociates at about 4175°F; specific gravity, 3.20; extreme hardness of 2500 Knoop, with excellent abrasion and erosion resistance; high thermal conductivity, 7 to 10 times that of fire clay; excellent resistance to thermal shock; maintains great strength to very high temperatures (PCE, 3350°F — cone 37 to 40); unique electrical qualities; relatively low thermal expansion; no inversion on heating; chemically acidic, with good stability. *Uses:* special refractories for boiler furnaces, ceramic kiln furniture, heat treating, hearth plates, high thermal conductivity muffles and retorts; electrical heating elements; lightning arrestors; metallurgical additions; also available in a Norton-patented process for coating graphite — in rocket nozzles and reaction motor parts, etc. — for increased resistance to erosion by high velocity gases.

MAGNESIUM OXIDE (MAGNORITE®)

Fused magnesia of highest purity. *Characteristics:* extremely high melting point, about 5,000°F; specific gravity, 3.58; electrical resistivity, 10^8 ohm cm at 1000°C; chemically basic. *Uses:* linings for metal melting furnaces; high temperature electrical insulation; refractories for handling corrosive caustic materials.

FUSED STABILIZED ZIRCONIA

Norton was the first to develop fused zirconia for practical commercial use. *Characteristics:* high melting point; thermal conductivity in British Units at 2000°F is 6.2 for dense shapes, 4.7 for insulating shapes, 2.8 for insulating grain; high resistance to abrasion and thermal shock; not wet by most molten metals; changes from a fairly good electrical insulator at low temperature to a conductor at 1000°C. *Uses:* refractories for extremely high temperatures; setter plates for titanates; furnace linings for high temperature gaseous chemical reactions; zirconium chemicals; metal melting furnace linings; catalyst carriers; heat exchange pebbles; reaction engine parts including jet and rocket liners.

BORON CARBIDE (NORBIDE®)

The hardest man-made material, an exclusive Norton development of boron carbide. *Characteristics:* high melting point, 4440°F; specific gravity, 2.50; compressive strength, 414,000 psi; bending strength, 44,000 psi; self-bonding, unaffected by all acid and alkali solutions. *Uses:* abrasive for economical replacement of diamond dust in lapping; high purity powder of micron sizings for use as refractory and in "cermet" combinations; neutron absorption in nuclear reactors or particle accelerators; pressure-blast nozzles; wearproof bushings, slides, etc.



In these Higgins type arc furnaces tremendous amounts of electrical energy are utilized by Norton in electrochemically refining crude minerals into basic Rx refractory materials.

BORON NITRIDE

Refined by Norton to over 98% purity. *Characteristics:* melts or dissociates at 5400°F; a nonconductor of electricity; weighs only 7 lbs. per cu. ft.; is not oxidized in air at 1200°F. *Uses:* anti-sticking agent for use with molten glass or metal; heat-resistant lubricant; thermal insulator in vacuum or atmosphere furnaces; experimental refractory or crucible material; experimental electrical insulator.

MANY OTHER MATERIALS

Among the high-melting, useful materials made available by Norton are Special Fused Oxides, Refractory Carbides, Refractory Borides, Mixed Borides, Elemental Boron. Research, development and field testing are being conducted on Experimental Borides, Carbides, Nitrides and Silicides. Some of these are in regular industrial use and new uses are being found for others.

AVAILABLE IN MANY STANDARD OR SPECIAL FORMS

Besides supplying these materials in their crude form, more or less as they come from the furnace, Norton has extensive facilities for processing and fabricating — and is ready to work with you in engineering any of these materials to your particular requirements.

GET THIS BASIC MATERIALS BOOKLET

This new Norton Publication, "Basic Materials," contains 22 pages of detailed information, including actual and suggested uses. For your copy, write to NORTON COMPANY, 329 New Bond St., Worcester 6, Mass. *Canadian Representative:* A. P. Green Fire Brick Co., Ltd., Toronto, Ontario.



NORTON

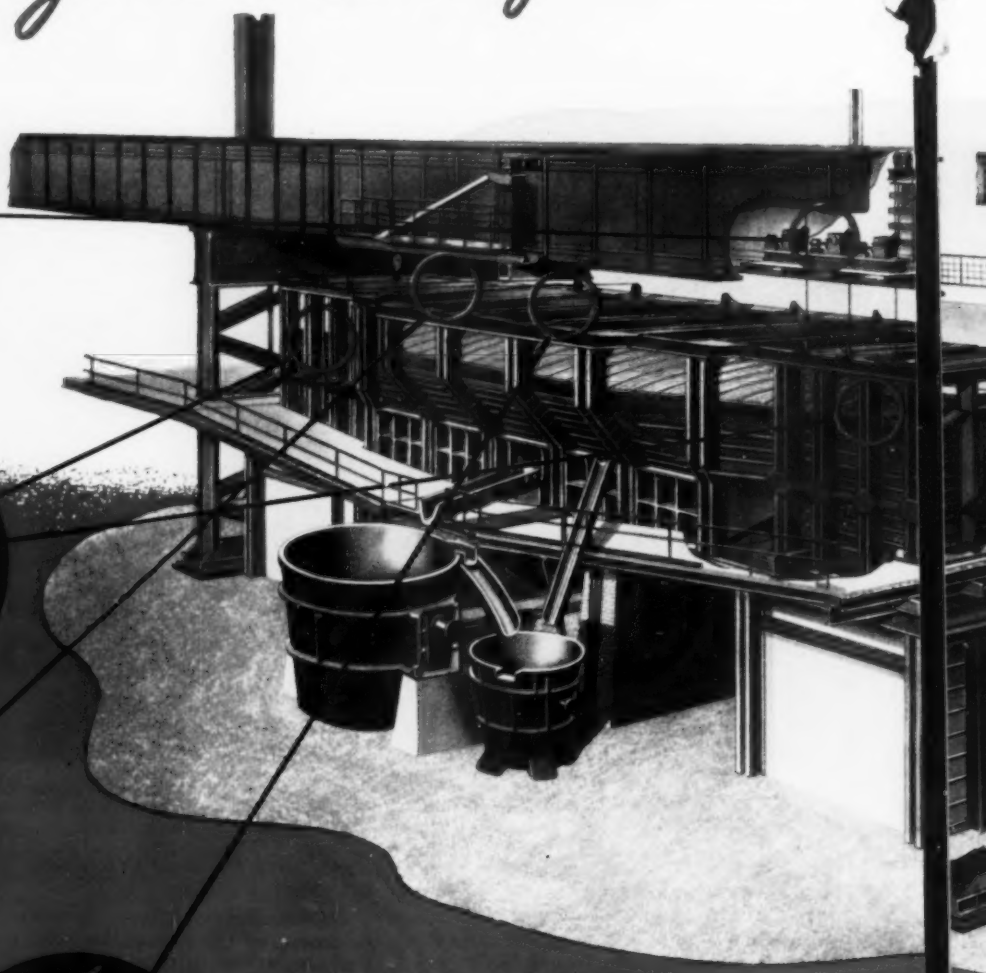
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*Trade-Marks Reg. U. S. Pat. Off. and Foreign Countries

OPEN HEARTH OPERATORS:

Have you asked yourself



DOOR DRIVES
Fluid Clutches to reduce cable wear?

PORT ENDS
Suspended basic or double downtake silica?

FURNACE PRESSURE CONTROL
Hydraulic, pneumatic or electronic?

FURNACE TEMPERATURE CONTROL
Roof or backwall block?

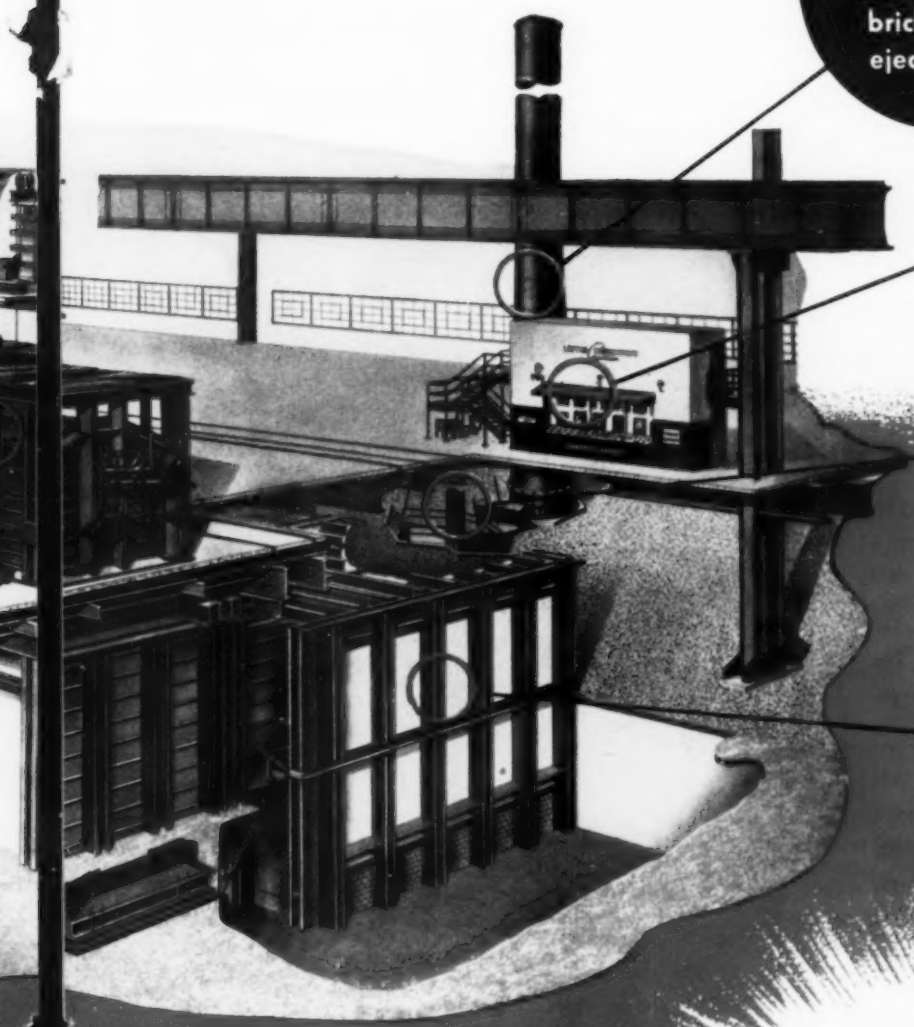
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Loftus
BUILDS 'EM BETTER

LOFTUS CAN HELP YOU!

The answers to these questions rest in the cumulative experience of Loftus engineers. This know-how covers open hearths of every size and type, tailored for specific needs in many countries

Loftus Designs and Builds Open Hearth Furnaces, Soaking Pits, Continuous Heating Furnaces, All Types of Heat Treating Furnaces, and 60-Cycle Induction Heating Furnaces.

these questions?



STACK
Conventional self-supporting brick lined or ejector type?

FUEL AIR RATIO
Pneumatic or hydraulic?

REVERSING VALVE DRIVE
Drum or crank type?

REGENERATOR
Single or double pass?

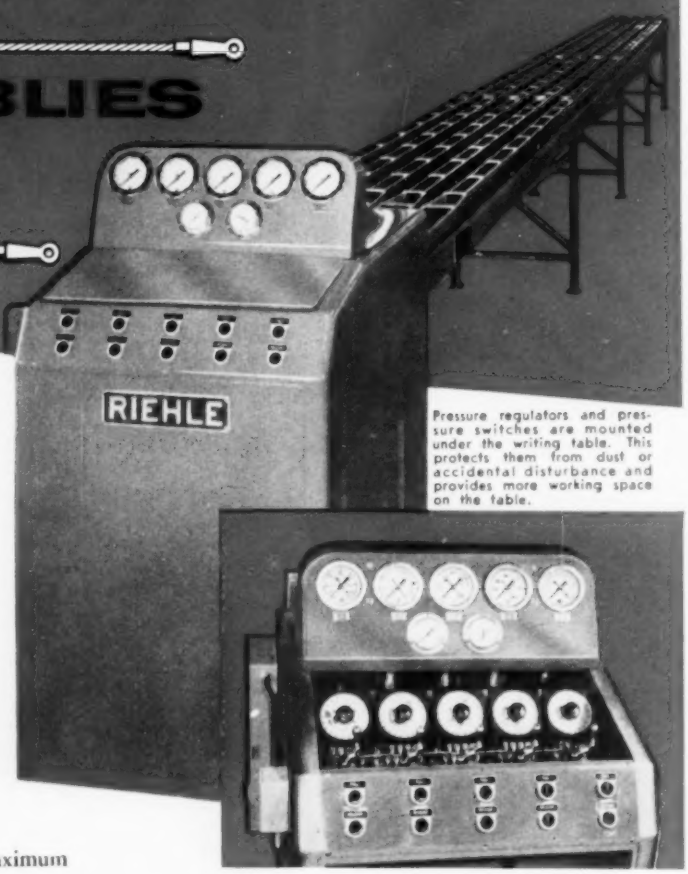
throughout the world. Each furnace, though individually designed and built to precise specifications, provides a flexibility in operation which insures the type of performance every steel maker demands.

SEND TODAY for this new, instructive brochure "Open Hearths by Loftus", an illustrated description of modern open hearth design and construction.



Loftus ENGINEERING CORPORATION
Designers and Builders of Industrial Furnaces
610 Smithfield Street, Pittsburgh 22, Pennsylvania

TEST AIRCRAFT CABLE ASSEMBLIES FASTER



Pressure regulators and pressure switches are mounted under the writing table. This protects them from dust or accidental disturbance and provides more working space on the table.

Up to five aircraft cables can be prestressed and proof-loaded at various loads and at one time on this new Riehle Aircraft Cable Tester.

By a turn of a handwheel, loads can be adjusted to any desired point within the range of the machine.

The duration and strain at each test station is preset on adjusters mounted under the writing table. After setting, the machine is operated by simply pressing the buttons on the console. When maximum strain has been exerted for the preset time interval, the machine automatically releases the load. After the load is released, the timers automatically reset to zero for the next test. The strain on each cable is recorded on large easy-to-read dials. Each dial has two hands; one records strain at any time and the other records the maximum.

The mooring table accommodates up to 50-foot lengths of cable. Tables for longer cable lengths are available. Safety guards are the open type so that the cable may be conveniently inserted.

The Riehle Aircraft Cable Proof Tester meets all specifications of the Bureau of Naval Aeronautics.

WRITE FOR LITERATURE, SPECIFICATIONS AND PRICES

RIEHLE TESTING MACHINES

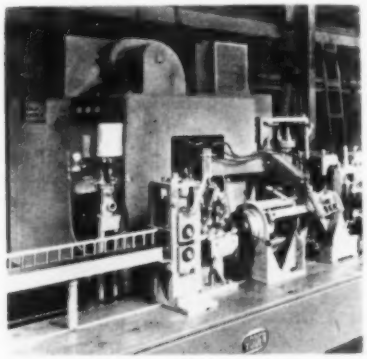
Division of American Machine and Metals, Inc.
EAST MOLINE, ILLINOIS

"ONE TEST IS WORTH A THOUSAND EXPERT OPINIONS"

engineering digest OF NEW PRODUCTS

Welded Nonferrous Tubing

The first two tube mills for converting coiled nonferrous strip at high speed into welded tubing, have recently been completed by the Yoder Co. Induction welding of nonferrous tubing by the new process is done at speeds ranging from 40 f.p.m. up to 120 f.p.m., from ten to thirty times faster than previously. It is claimed that physical tests show that the tensile strength in the weld zone is increased about 15%. The weldable metals include almost the entire range



of aluminum alloys available in coiled sheet form, certain magnesium alloys, a wide range of brasses and other copper alloys, nickel and nickel alloys, such as monel and inconel; also austenitic and ferritic stainless steels and the lighter gages of carbon steels. The present capacity ranges from ¾ in. to 4 in. tubing, in gages from 0.025 in. up to 0.134 in. bringing the thickness diameter ratio down to 1%.

For further information circle No. 966 on literature request card on p. 32-B.

Die Casting Stripper

Enthone, Inc., has announced a new nondeteriorating electrolytic stripper for stripping electroplated metals from zinc die castings. This stripper is used at 6 volts, at temperatures to 180° F. and forms a passive film over those surfaces already stripped.

For further information circle No. 967 on literature request card on p. 32-B.

Arc Welding

The Hobart Brothers Co. will exhibit two entirely new air cooled gasoline engine driven arc welders for the first time at the National Metal Exposition in Cleveland, October 19 to 23rd. One is a low cost 200-ampere d.c. arc welder powered by a 2 cyl-



inder Wisconsin air cooled engine. The other is a combination 200 ampere a.c. arc welder and 5 kw. a.c. power unit, converted by merely throwing a switch.

For further information circle No. 968 on literature request card on p. 32-B.

Portable Ultraviolet Unit

Menlo Research Laboratory has developed a compact new flashlight-type portable ultraviolet instrument. This 1¾ lb. instant starting unit is pow-



ered by two flashlight batteries, and is adapted to such uses as mining, metal products engineering and manufacturing, leak detection and materials flaw or crack tests.

For further information circle No. 969 on literature request card on p. 32-B.

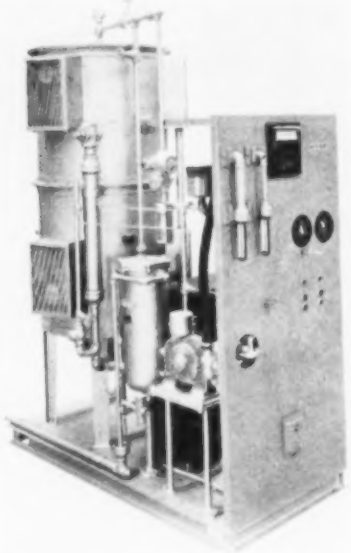
Nitrogen Generator

A nitrogen generator produced by Baker and Co. Inc., will be exhibited at the National Metal Exposition in Cleveland, October 19 to 23. This generator produces a gas completely free of oxygen, consisting of nitrogen, water vapor and hydrogen between 0.25 and 25% as controlled.

For further information circle No. 970 on literature request card on p. 32-B.

Endothermic Gas Generator

Hevi Duty Electric Co. announces a new endothermic gas generator for controlled atmosphere heat treating operations. The generator is a complete package unit, consisting of the



air filter, air gas mixing machine, gas cracking chamber, gas cooler, control panel, and power transformer. The manufacturer states that chemical analysis is consistent and that no special supervision is required. A capable operator makes the settings.

For further information circle No. 971 on literature request card on p. 32-B.

Rust Inhibitor

A new rust inhibiting oil additive for protection of ferrous surfaces is now available in commercial quantities from Atlas Powder Co. Immediate indicated uses include the protection of stored aircraft engines (both piston and jet), diesel and gasoline engines, turbines, pipe lines, and ferrous tools or components in production stages. The new inhibitor is a



FURNACES OF TOMORROW

At Lindberg Engineering Company in Chicago and at associated companies throughout the world, scientists and engineers, assisted by leading research groups such as Battelle Memorial Institute, constantly research, design, develop and test advanced types of metallurgical and heat treating equipment . . . equipment that helps American industry lead the world in the science and application of heat treating . . equipment such as . .

LINDBERG

Today!

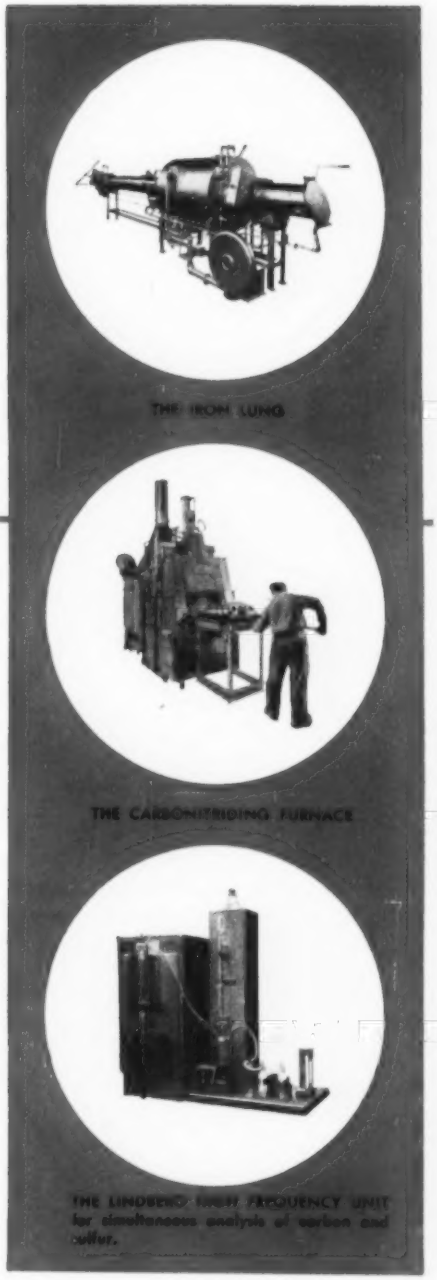
. . the Lindberg "Iron Lung" for bright hardening and annealing stainless steel *completely free from oxidation and discoloration.*

. . the Lindberg Carbonitriding Furnace, a self-contained *five-furnaces-in-one* unit not only for carbonitriding, but also for hardening, carburizing, annealing and carbon restoration.

. . the Lindberg High Frequency unit which permits, for the first time, determination of both carbon and sulfur contents of iron and steel in a *single operation.*

Equipment development at Lindberg includes years of field operation. The Iron Lung, for example, had been tested for three years before announcement . . in a dozen plants throughout the country.

There is probably a Lindberg Furnace on field test today, that will solve a problem for you in 1956.



FURNACES

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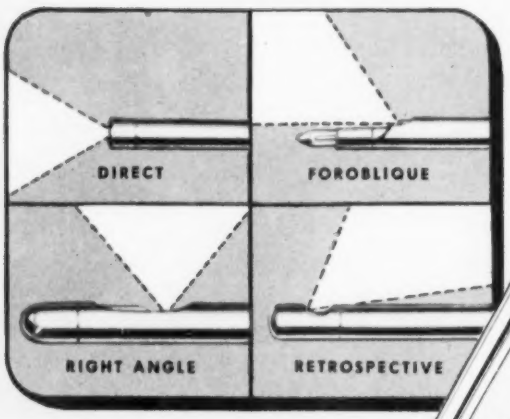
INSPECTION OF CONFINED AREAS FACILITATED

NECESSITY OF DISMANTLING AVOIDED

TIME SAVED—MONEY SAVED



A.C.M.I. BORESCOPES



A.C.M.I. Borescopes are available in 4 angles of vision (as above)— in diameters of .120" to 4.00"— in lengths of 4" to 720". Special models for special problems.

The A.C.M.I. Borescopes permit close-up visual examination of interior areas and surfaces not otherwise visible. They save time and money, and prevent costly dismantling, by providing a practical solution to a wide variety of inspection problems.

In maintenance and inspection work, on small internal bores, machine parts or castings, to large boiler tubes, chemical plants, process equipment, or other industrial installations, an A.C.M.I. Borescope may be the answer to *your* problem.

Each Borescope is a compact, self-illuminated industrial telescope of highest quality, employing a precision optical system, that produces a flat visual field. Lens systems are fully corrected for color, spherical aberrations, and coma, with all lens surfaces coated to increase light transmission.

Write for free informational folder, or tell us your problem.

American Cystoscope Makers, Inc.

1241 LAFAYETTE AVENUE NEW YORK 59, N. Y.

sorbitan mono fatty acid ester. In performance and economy the new material under many conditions shows substantial improvement over former inhibitors.

For further information circle No. 972 on literature request card on p. 32-B.

Metallizing Machine

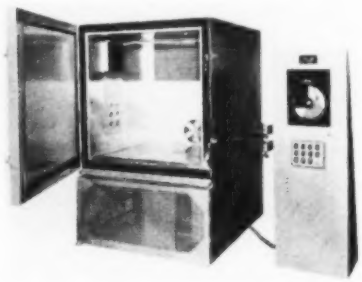
A metallizing machine incorporating improvements has been announced by Vandersee Engineering Co., Inc. The machine is intended to be lightweight, compact, easy to operate and to remove the element of chance from metallizing operations. All the bearings for the wire feed mechanism are encased in the main body gear case casting, for perfect gear alignment and easy repair. Other big improvements are the gas mixing chamber eliminating backfire, and elimination of nozzle adjustments to assure an even flow of metal.



For further information circle No. 973 on literature request card on p. 32-B.

Humidity Chamber

American Research Corp. has announced a 64 cu. ft. humidity simulation chamber. A special feature of this cabinet is that it will reproduce relative humidity from 20 to 100%, and also simulate rain fall at 4 in. per hour, fully automatically on a programmed cycle.

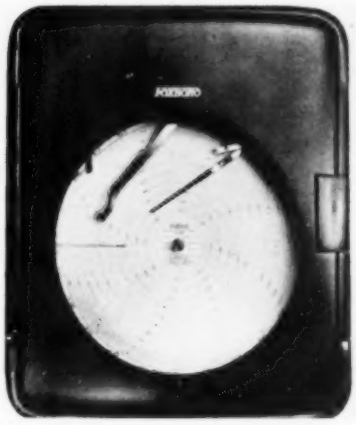


For further information circle No. 974 on literature request card on p. 32-B.

Openhearth Furnace Reversal Regulator

Automatic reversal of openhearth furnaces is now being accomplished by a multiple-record electronic instrument made by the Foxboro Co. The instrument uses temperature measurements, by thermocouple or radiation units, as the basis for furnace reversal. The use of an easily-filled circular chart, with each record in a different color, facilitates a daily check on operating conditions. Additional records of stack and steam temperatures, up to a total of six records, can be provided on the same chart. Bull's-eye lights may indicate direction of firing.

Reversal is initiated by the temperature difference between the two checkers reaching a pre-set value, or by the temperature at either checker reaching a pre-set maximum. Reversal by temperature difference allows reversal time to be a function of the temperature of the waste gases,



thus helping to keep the regenerative system in balance. An external setting knob on the recorder permits the furnace operator to adjust the temperature difference setting when shorter reversal periods are desired toward the end of the heat. High temperature reversal provides an override control, and operator warning alarms can be furnished.

For further information circle No. 975 on literature request card on p. 32-B.

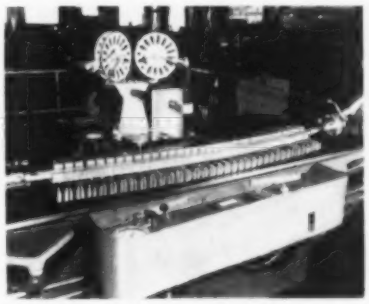
Contact Material

A new precious metal contact material laminated in ingot form is announced by the D. E. Makepeace Co. The new material consists of one or more ingots of precious metal bonded to a base metal in any strip width or thickness, and in required tempers. The finished pieces result from blanking or shearing the strip, which eliminates contact assembly operations.

For further information circle No. 976 on literature request card on p. 32-B.

Stretch Form Blocks

Northrop Aircraft, Inc., announces plans for the manufacture of its recently developed flexible stretch form block. Hufford Machine Works has been awarded an exclusive license to manufacture and market this auxiliary equipment for existing types of stretch form presses. This equipment provides an economical method of



producing preproduction quantities of curved sections without having to invest in expensive dies.

For further information circle No. 977 on literature request card on p. 32-B.

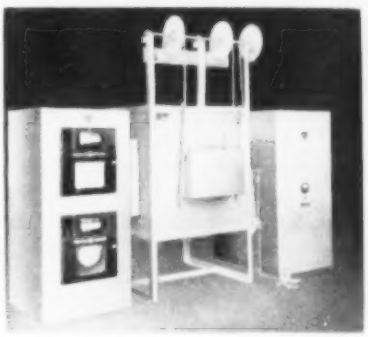
Ductile Iron Bar Stock

Howard Foundry Co. has developed a new engineering material in producing ductile iron bar stock. Howard is producing bars that are sound from one end to the other, and will pass X-ray inspection for density. Bars are supplied in 12 in. lengths, in round sizes of 1¼, 1¾, 2¼, 2¾, 3⅜, 4⅜, and 6 in. The as-cast average properties of Howard's ductile iron bars are 100,000 psi. tensile strength, 65,000 psi. yield, 3½ to 4½% elongation and 245 Brinell hardness. Bars can be heat treated for greater elongation and hardness.

For further information circle No. 978 on literature request card on p. 32-B.

Heat Treating Furnace

A general purpose heat treating furnace for use throughout the full heat treat range has been announced by the Pereny Equipment Co. The new unit is designed to handle all require-



ments at continuous heavy duty up to 2500° F., or higher temperature work over shorter periods. Loading area is 14 x 24 x 12 in., and the outside dimensions are 50 x 52 x 84 in., excluding panels. It features ports

Meaning of
JOB
SIDE



Let's assume you want to better your grinding operation. You let Electro's technical expert see your present situation.

He comes to your job-side without cost or obligation to you.

From his skill and experience in working with many situations, supported by a young, pleasantly aggressive, creative manufacturing organization, anxious to win on merit . . . he and the organization resolves what is seen at your job-side and what you'd like to better, into a "specific-purpose" grinding wheel, for your job.

In due time a test is run. At your job-side the Electro "specific-purpose" grinding wheel, whether resin or vitrified, thus competently specified for your job . . . will produce the better results sought.

To take advantage of this job-side service all you need to do is write, phone or wire: "Ask your representative to call on me."

Electro Refractories & Abrasives Corporation • 344 Delaware Ave., Buffalo 2, N. Y. • *Manufacturing Plants:* Buffalo, • Electric Furnace Division, Cap-de-La-Madeleine, P. Q., Canada • Regional Warehouse: Los Angeles 58, California Grant S. Diamond, President.

Electro
TRADE-MARK
SINCE 1919

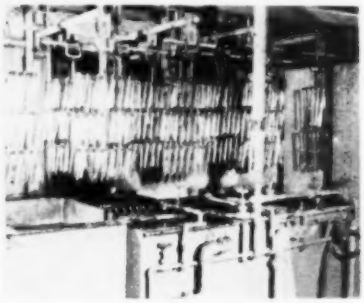
E-440

for connecting atmosphere-reducing sources, an air-operated door, automatic flame curtain, easily replaced elements with air-cooled terminals, and appurtenant electrical equipment.

For further information circle No. 979 on literature request card on p. 32-B.

New Bright Nickel

The Hanson-Van Winkle-Munning Co. has announced a new organic-type bright nickel process. It is claimed that both installation and operating costs are lower. Equipment suitable for a Watts nickel bath is all that is required. Ordinary auxiliary equipment may be used, filtration may be either periodic or continuous, ventilation is not required, and heat demands are up to 25% lower. Deposits with this process have a bright white color, reduced surface roughness, controllable low internal stress, good ductility and highly active surfaces. Bath temperatures, current densities, and plating speeds may be varied considerably to meet various specifications and production schedules. It is further claimed that normally no batch purification treatment is needed, thin deposits are bright, surface preparation is held to a minimum, reject-stripping costs are low, while rejects are few, baths have high tolerance to impurities, the process is easy to control, and it uses regular nonpremium nickel anodes.



For further information circle No. 980 on literature request card on p. 32-B.

Recording Galvanometers

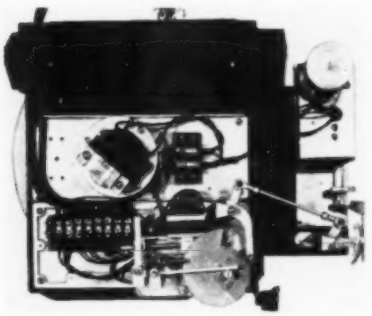
Improved techniques of balancing and a completely redesigned suspension system are combined in Consolidated Engineering's new recording galvanometers to control linearity, sensitivity, damping, balance, and zero stability. Fourteen models offer flat frequency ranges from 0 to 11 cps. to 0 to 3000 cps. Undampened d.c. current sensitivities range from 4.6 micro-amperes per inch to 40 milliamperes per inch. Rotatable lens mounts permit use in oscillographs of different optical bases. All lens and window surfaces are magnesium fluo-

ride coated. The instruments can be used at altitudes up to 100,000 ft. Both installation and adjustment have been made easier.

For further information circle No. 981 on literature request card on p. 32-B.

Flow Meter

A new flow meter of the electronic type has been announced by the Hays Corp. This meter is available in several different models for indicating, recording and measurement of the flow of fluids such as steam, water, and other fluids and gases. The meter is designed for differentials of from 20 to 750 in. water, with a standard static operating pressure of 1500 psig. or higher. It is available for the measurement of liquid level in an en-



closed vessel as well as for flow, pressure, and temperature combined. Other features include: unaffected by normal voltage, frequency, temperature variations or reasonable length of transmission lines; maximum sensitivity; 3 to 1 range calibration at recorder; great speed of response; high accuracy; 12 in. uniformly graduated charts; no integrator creep at zero; easy micrometer zero adjustment; indicators can be calibrated to read directly.

For further information circle No. 982 on literature request card on p. 32-B.

Hard Coating Aluminum

A new process for the hard-coating of aluminum is now in use by Anodic, Inc. The hardened surface, generally 0.002 in. thick, which approximates case-hardened steel or chromium plating, has a very high resistance to abrasion and corrosion, a high dielectric strength, and a low coefficient of friction. In corrosion resistance it will withstand 5000 hr. of the standard salt-spray test as compared with the 250 hr. requirement for usual anodic finishes. The MHC (Martin Hard-Coating) Process creates an amorphous coat of aluminum oxide about ten times thicker and 30 to 100% harder than other anodizing processes; it can be classified as "file-hard". The exact growth can be controlled within very close tolerance. In general it is best applied to those alloys containing less than 5% copper or 8% silicon. The coating can be applied selectively, or to the entire surface. Its color is determined by the alloy, ranging between amber and black. A rough surface will be made smoother, while a very smooth surface will be slightly roughened. When used to salvage parts that have been overmachined, the coating can be built up to 0.008 in. in thickness. Anodic, Inc., is operating under the first commercial license issued by the Aluminum Company of America for the MHC Process, and is devoting its entire facilities to this work.

For further information circle No. 983 on literature request card on p. 32-B.

Induction Soldering Machine

A special induction heating unit designed specifically for soft soldering and silver brazing is announced by Radio Frequency Co. A unique circuit and output transformer arrangement permits rapid heating of small hard-to-load-into parts, using single turn, or even half turn work coils which can be safely touched during rapid loading and high production operation. The machine is adapted to soldering glass metal terminals as well as other hermetic soldering, and can be set up for a new job in a matter of minutes.



For further information circle No. 984 on literature request card on p. 32-B.

Powder Lance

Linde Air Products has introduced a metallic-powder lance which produces an exothermic reaction with higher temperatures than oxygen



lances. It is stated that an operator may easily and efficiently cut holes in blast furnace salamanders, ceramic materials, and steel or cast iron containing incrustations or inclusions.

For further information circle No. 985 on literature request card on p. 32-B.

Heating Extrusion Dies

Magnethermic Corp. has announced a new line of 60-cycle induction die heaters to preheat extrusion dies. Conventional heating methods in use today require 60 min. or more for preparing a die. With induction heating, a small or medium size die can be preheated in 4 to 10 min. The smallest unit on which production has already commenced is rated at 15 kw. This heater will handle dies for most standard presses up through 1500 tons. The heater is arranged for operation on either 220 or 440 volts, 60-cycle.

For further information circle No. 986 on literature request card on p. 32-B.

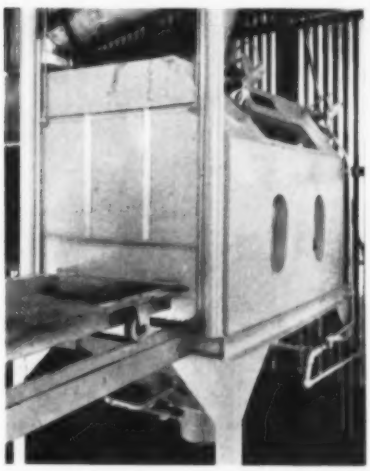
Iridium Radiography

Iridium radiography sources for the nondestructive testing of steel from ¼ to 1 in. with high sensitivity are now available from Tracerlab, Inc. Iridium sources will provide 2% definition in steel in this range. Iridium-192 allows thin sections of steel and other less dense materials to be radiographed and reveals flaws which would be undetectable if high-energy gamma sources were used.

For further information circle No. 987 on literature request card on p. 32-B.

Wet Blast Cabinet

A new precision wet blast cleaning cabinet has been announced by the Vacu-Blast Co. The manufacturer



emphasizes that the machine has no pump to wear out, and that the blast gun is more efficient.

For further information circle No. 988 on literature request card on p. 32-B.

Protective Coating

Ucilon 454, an air-drying modified vinyl coating, has been introduced by United Chromium, Inc. This coating can be applied by ordinary brushing and spraying techniques. When sprayed, it can produce dry films of 0.003 to 0.005 in. per coat. Two coats are sufficient for most applications. Ucilon 454 resists acids, alkalies, salts,

how Tinnerman Products solved



a tough heat-treating problem:



with Gulf Super-Quench

- minimum hardness was increased from 50 to 60 RC
- variation in hardness was reduced from ±5 to ±2 RC

on AISI C-1064 STEEL

Tinnerman Products, Inc., Cleveland, Ohio, manufactures a large variety of spring clips and spring fasteners of the type pictured at the left. These parts range in thickness from .01 to .062 inches and are all made of AISI C-1064 spring steel.

Normal heat treating practice calls for heating to 1600 deg. F. in a controlled atmosphere. The parts are held at this temperature for approximately ½ minute, then are transferred by a shaker-type conveyor into the quenching bath, which is held at 120 to 125 deg. F. After quenching, the parts are tempered at 700 deg. F.

When Tinnerman used a conventional quenching oil, hardness varied from 50 to 60 RC—too low and too variable for suitable performance characteristics. Examination of the steel revealed that in all cases it was within specification limits.

After investigating a number of other quenching oils, Tinnerman Products discovered one that is outstanding—Gulf Super-Quench. Tinnerman Products is now quenching all of these parts in Super-Quench with remarkable results. Hardness is never lower than 60 RC and averages 62 ± 2. This improvement was obtained without any change in quenching temperature, degree of agitation, analysis, or grain size.

If you, too, are looking for ways and means to increase the efficiency of your quenching operation, it will pay you to investigate the advantages of Gulf Super-Quench. Write, wire, or phone your nearest Gulf office.

Gulf Oil Corporation · Gulf Refining Company

Pittsburgh 30, Pennsylvania

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water, and is especially recommended to protect equipment against petroleum and its derivatives.

For further information circle No. 989 on literature request card on p. 32-B.

Resistance Welding

Raytheon Manufacturing Co. has announced a resistance welding head to be exhibited at the National Metal Exposition in Cleveland Public Auditorium, October 19 to 23rd. The new



head incorporates improvements such as accurate pressure and follow-up controls, visual pressure scale and mounting, which allows use in either a vertical or horizontal plane.

For further information circle No. 990 on literature request card on p. 32-B.

Flaw Locater

Accurate, on-the-spot inspection for metal soundness can now be made on any metal at any location, through the medium of a portable Turco Dy-Chek flaw location kit. The light, compact, metal kit can be carried in one hand easily. Dy-Chek materials are applied in the field in basically the same manner as they are applied in the plant.

For further information circle No. 991 on literature request card on p. 32-B.

Torsion Spring Tester

John Chatillon and Sons announces a new, standard universal and production tester for spiral and torsion springs, up to 1 in. long and 2 in. o.d. It will test spring capacity up to 2000 gram centimeters in increments of 0.1 gram centimeter. Deflection is read to ½ degree. The tester is also furnished with a magnetic damper for

fast reading. An accurate check of the tester's calibration can easily be made by using standard weights.

For further information circle No. 992 on literature request card on p. 32-B.

Portable Mixers

Chemineer, Inc., announces manufacture of a complete line of portable fluid agitator and mixer units, both direct and gear driven. Sizes range from ¼ to 3 hp. in 1750, 1150 and



420 r.p.m. Important features are lubricated gears integral with motor on slow speed units, pre-lubricated and sealed agitator shaft bearings, full swivel clamp, and a complete line of mounting accessories.

For further information circle No. 993 on literature request card on p. 32-B.

Nondestructive Testing

The new ultrasonic Metroscope has been announced by J. W. Dice Co. for measuring and testing of metals and



other materials. Signal-to-noise ratio, picture clarity and line voltage correction are greatly improved over the maker's original model. The new instrument is particularly useful where wall thickness measurements or tests must be made from one side of the material only, or in finding internal defects of a laminar type in sheet materials, clad metals, and cutting tool tips.

For further information circle No. 994 on literature request card on p. 32-B.

Castings Impregnant

A new plastic sealant for impregnating pressure castings has just been announced by Tincher Products Co. This sealant can be washed off with water, hardens without evaporation, shrinks 15 to 50% less than other plastic seals, and is not brittle when set, it is claimed.

For further information circle No. 995 on literature request card on p. 32-B.

Cast Titanium

National Research Corp. has announced the development of a method for the production of pilot quantities of cast shapes of both pure and alloyed titanium metal. Castings of complex shape weighing up to several pounds have been made. Carbon, oxygen, and nitrogen content are reasonably comparable with commercial wrought titanium. The surface attainable is equal to that of good sand cast metals.



For further information circle No. 996 on literature request card on p. 32-B.

Electric Furnaces

The L & L Mfg. Co. has announced an entirely new line of electric furnaces, heated by new Dyna-Glow elements. The furnaces are available in 2050 and 2300° F. temperature ranges, for either front or top loading.

For further information circle No. 997 on literature request card on p. 32-B.

Plating Bath Test

R. O. Hull & Co. has announced equipment for testing bath composition, plating range, throwing power, optimum agitation, proper cleaning and current distribution. Unit is suspended on a cathode busbar.

For further information circle No. 998 on literature request card on p. 32-B.

Ladle Stopper

Electro Refractories and Abrasives Corp. has announced a new type of ladle stopper, which it is said will not crack from heat shock. The stopper is made of fire clay, graphite and a special synthetic ingredient, and is said to suffer only slight change in contour due to erosion by molten steel.

For further information circle No. 999 on literature request card on p. 32-B.

Stepless Temperature Control

The West Instrument Corp. announces a new modulated temperature controller for unusually close control. The manufacturer claims that this instrument holds temperatures with no



under or over shooting, using only enough power to the heating element to hold the temperature setting, resulting in longer heater life. The true temperature is indicated on a 5 in. scale, mirrored for parallax correction.

For further information circle No. 1000 on literature request card on p. 32-B.

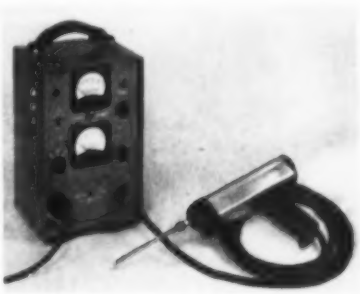
Test Chamber

A new unit designed for high and low temperature testing, has been announced by Sub-Zero Products Co. Available in capacities from 1 to 4 cu. ft., the new unit will operate at temperatures from 250 to —130° F. at uniform distribution.

For further information circle No. 1001 on literature request card on p. 32-B.

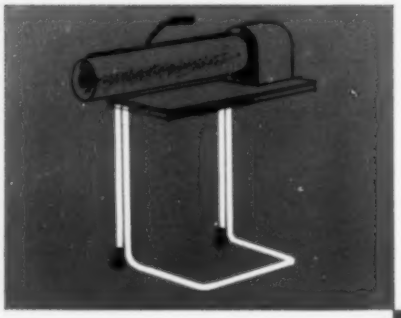
Leak Detector

General Electric's halogen-sensitive leak detector has been redesigned to permit easier detection of leaks in closed systems. The portable instrument can detect a leak so small that

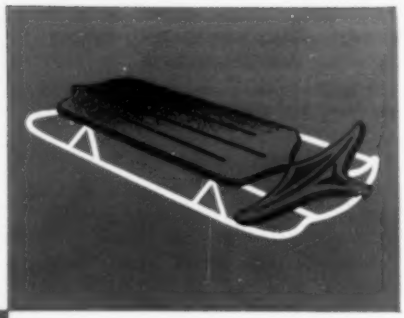


only 1/100 oz. of gas will pass through the opening in a year. Leak indication can now be simultaneously indicated by means of the dial, earphone attachment, or built-in loudspeaker.

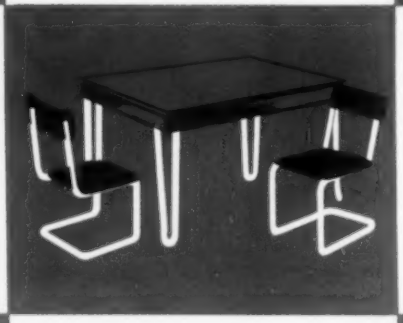
For further information circle No. 1002 on literature request card on p. 32-B.



OSTUCO TUBING is versatile!



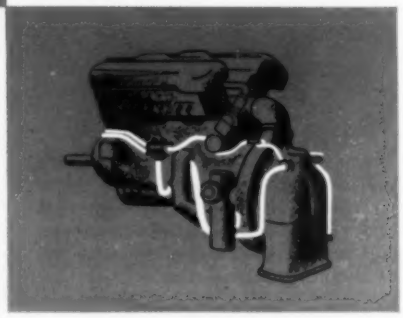
OSTUCO TUBING is versatile!

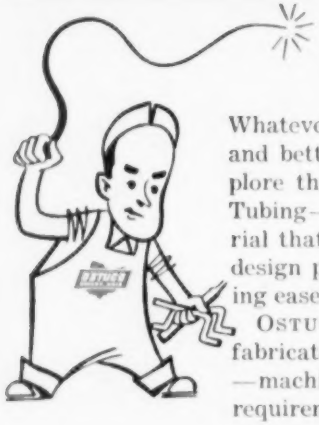


OSTUCO TUBING is versatile!



OSTUCO TUBING is versatile!





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WHAT'S NEW
IN MANUFACTURERS' LITERATURE

1036. Abrasion Tester

Bulletins on durable precision instrument for testing resistance of surfaces to abrasion. *Taber Instrument*

1037. Abrasive Belt

Folder on belt for finishing carbide tools. *Behr Manning*

1038. Abrasive Wheels

Operating suggestions and recommended wheels for finishing stainless. *Manhattan Rubber Div.*

1039. Alloy Castings

8-page bulletin on alloy castings for heat treating. *Ohio Steel Foundry*

1040. Alloy Hearth

Bulletin 112 on cast Ni-Cr hearth for heat treating furnaces. *Fahralloy*

1041. Alloy Selection

Chart to select alloy for given corrosive problem. 350 corrosives included. *Cooper Alloy Foundry*

1042. Alloy Steel

16-page book on type 9115 low-alloy high-strength steel. Properties, fabrication, welding. *Great Lakes Steel*

1043. Alloy Steel

68-page "Aircraft Steels" book includes revised military specifications. Also stock list. *Ryerson*

1044. Alloy Steel

32-page book on abrasion resisting steel. Properties, fabricating characteristics, uses. *U. S. Steel*

1045. Aluminum Alloy

Analysis, properties, outstanding features of new high-purity aluminum alloy. *Fromson Orban*

1046. Aluminum Bronze

Bulletin 33 on properties and uses of Ampco metal. *Ampco*

1047. Aluminum Castings

Bulletin on quality control methods employed in making aluminum castings. *Permold*

1048. Aluminum Die Castings

Bulletin on design and manufacture of aluminum die castings. *Hoover Co.*

1049. Aluminum Heat Treating

8-page Bulletin 5912 on solution heat treating, annealing, stabilizing and aging of aluminum. *General Electric*

1050. Ammonia for Heat Treat

Booklets on "Applications of Dissociated Ammonia," "Ammonia Installations for Metal Treating," "Nitriding Process," Carbonitriding." *Armour*

1051. Annealing

Experience at Johns-Manville with atmosphere furnace for annealing gaskets and miscellaneous parts. *Sunbeam*

1052. Annealing Furnaces

8-page illustrated booklet on continuous annealing furnaces. Schematic diagrams, photographs, and actual production data. *Drever*

1053. Anodizing

Data on aluminum racks with copper hooks for anodizing. *National Rack*

1054. Arc Welders

Data on line of arc welders. *Viking Div.*

1055. Barrel Finishing

Folder on design and advantages of barrel finishing machine. *Minnesota Mining & Mfg.*

1059. Bending

18-page brochure on bent and welded rings, flanges, angles, bands. Tables of areas of circles, decimal equivalents. *King Fifth Wheel*

1060. Bending and Cutting

Folder describes hand and air-operated bender-cutter and its applications. *J. A. Richards.*

1061. Beryllium

20-page booklet describes beryllium products, including the pure metal, oxide and alloys. *Beryllium Corp.*

1062. Bimetal Applications

32-page book on application of thermostatic bimetal. Property charts for 30 types. Design formulas. *W. M. Chace*

1063. Black Oxide Coatings

Data on black oxide coatings for steel, stainless steel and copper alloys. *DuLite*

1033. Combustion Handbook

SELECTION, installation and operation of oil and gas combustion equipment for industrial processing will be facilitated by reference to this third edition of Hauck's *Industrial Combustion Data*, a 168-page hard-bound handbook, 8½ x 11 in. size, and teeming with 299 illustrations and 317 data tabulations.*



Intended for combustion engineers, plant operating men and production executives, the book is based on extensive experience of the publisher's company in the field, plus much additional material from several authoritative outside sources.

Introductory section takes the form of detailed definitions of 138 technical terms pertaining to combustion processes, and 86 heat treatment terms.

Following are 32 pages of general industrial heating data, listing thermal properties of solids, liquids, gases, refractories, metals, alloys and fuels; and presenting drawings of practically all types of furnaces, boilers and kilns.

The text then proceeds to examine details of all types of oil burners, both low- and high-pressure, together with a consideration of fuels and related factors incident to oil firing.

The same applies to succeeding sections on gas firing as a process, and gas burners and accessories.

Concluding portion of the work presents general physical data—physical properties of liquids, solids and gases; temperature-pressure relationships, and conversion tables.

* Published by Hauck Mfg. Co. Copies are available to readers of Metal Progress who circle No. 1033 on request card, page 32-B.

1056. Barrel Finishing

Bulletin LCC-53-1 on compounds for barrel finishing, descaling, deburring, finishing, coloring and burnishing. *Lord Chemical Corp.*

1057. Barrel Finishing

22-page book on single-unit installation to yield savings up to 95% in finishing various parts. *Almco Div.*

1058. Barrel Plating

Folder on barrel plating with unique contact arrangement for maximum current distribution. *Daniels*

1064. Black Oxide Finish

Folder on penetrating black finish for ferrous metal. *Puritan Mfg.*

1065. Blackening Stainless

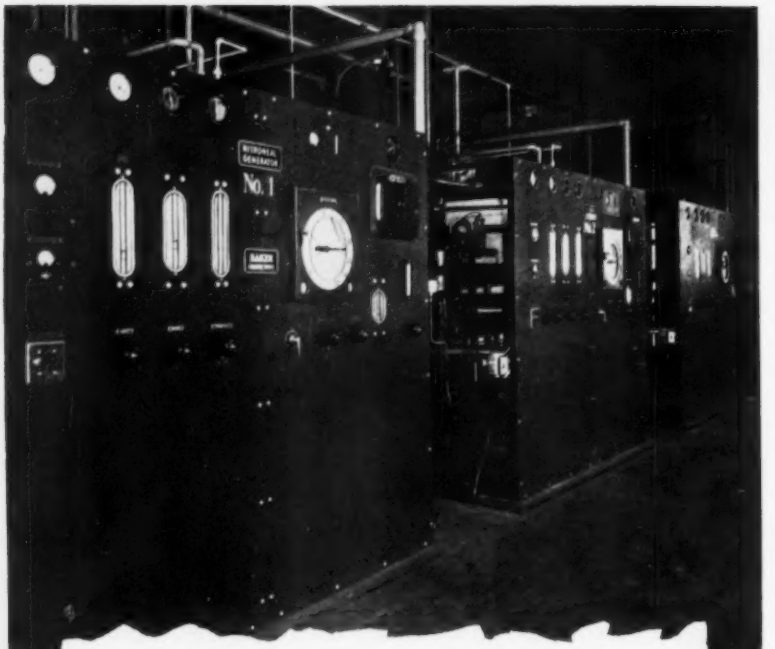
Bulletin on process for blackening stainless steels, cast and malleable irons. *Mitchell-Bradford*

1066. Boron Nitride

Data Sheet 513B on properties and possible uses of boron nitride. *Norton*

1067. Braze-Carburize

Article on simultaneous brazing and carburizing of hand tools. *Ajax Electric*



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1068. Brazing

12-page booklet on furnace and induction brazing. Methods and economy of process. *General Electric*

1069. Brazing Applications

48-page manual on all aspects of silver brazing applications and problems. *American Platinum Works*

1070. Brazing Stainless Steel

Illustrated booklet, "Bright Annealing, Hardening and Brazing Stainless Steel," describes conveyor furnace and bright brazing alloy. *Sargeant & Wilbur*

1071. Bright Annealing

Reprint on bright annealing of copper in atmosphere furnace. *Holcroft*

1072. Bronze

Folder gives tables of properties, uses, forms and other data on phosphor bronzes. *Chase Brass & Copper Co.*

1073. Burners

16-page bulletin on selection of gas burners. *Western Products*

1074. Burners

Bulletin on combination gas and oil burner. *Ra-Diant Products*

1075. Carbide Segregation

Effect of carbide segregation in tool steel. *Latrobe Steel*

1076. Carbon Control

Catalog T-623 describes the Microcarb control system that continuously measures the active carbon in the furnace atmosphere during heat treatment. *Leeds & Northrup*

1077. Carbon Control

Technical report on instrument for control of carbon potential of furnace atmospheres. *Lindberg Eng'g*

1078. Carbonitriding

Literature on Ni-Carb (carbonitriding) treatment for surface hardening. *American Gas Furnace*

1079. Carburizing

16-page bulletin SC-134 reviews gas carburizing techniques and possibilities. *Surface Combustion*

1080. Carburizing Salts

Folder on salts for liquid carburizing. *Swift Industrial Chemical*

1081. Castings, Bronze

16-page booklet on sand and centrifugal castings. *Amer. Non-Gran Bronze*

1082. Centrifugal Castings

Bulletins on machine parts and assemblies produced for centrifugal casting of nonferrous metals and special iron alloys. *Shenango Penn Mold*

1083. Centrifugal Castings

62-page book of centrifugally cast iron, steel, gray iron parts. ASTM specifications. *American Cast Iron Pipe*

1084. Chromate Coatings

Folder gives characteristics and uses of chromate conversion coatings on nonferrous metals. *Allied Research*

1085. Cleaners

12-page catalog on metal cleaners. Table of recommended practices. *Klem Chemicals*

1086. Cleaning

6-page bulletin includes concentrations for various metal cleaning applications and a handy list of cleaners for general industrial use. *E. F. Houghton*

1087. Cleaning

12-page Bulletin 68 deals with factors to consider in selecting metal cleaning equipment. *Despatch Oven*

1088. Cleaning

Bulletin on equipment for cleaning and pickling of shell cases and other ordnance items. *Alvey-Ferguson*

1089. Cleaning Compounds

16-page manual on finishing method for deburring and burnishing small metal parts. Compounds for heat treat scale removal and rustproofing. *Minn. Mining*

1090. Cleaning Equipment

Series of bulletins on dry cleaning process, degreasers, metal parts washers, degreasing solvents, emulsion and alkaline cleaners and rust-proofing compounds. *Detrex Corp.*

1091. Coatings, Metal

High-vacuum evaporation of metals set forth in detail in 12-page booklet. *Consolidated Vacuum Corp.*

1092. Cobalt Alloy

12-page booklet, "Haynes Alloy No. 25," tells of the unique properties of this cobalt-base alloy. *Haynes Stellite*

1093. Combustion Control

20-page booklet on combustion of various fuels and portable instrument to measure content of oxygen and combustibles. *Cities Service Oil*

1094. Compressors

12-page data book 107-C gives engineering information on characteristics of turbo-compressors. 18 types of application described. *Spencer Turbine*

1095. Continuous Casting

24-page book, "Better by the Mile," describes how the Rossi continuous casting machine works. History of continuous casting. *Scovill Mfg.*

1096. Controlled Atmospheres

24-page bulletin describes production problems with reference to dry atmospheres. *Pittsburgh Lectrodryer*

1097. Controlled Atmospheres

Bulletin 753 on generator for atmospheres for hardening, brazing, sintering and annealing carbon steels. *Hevi Duty*

1098. Controllers

24-page Bulletin 202-8 on automatic temperature controllers of the potentiometer and resistance-thermometer types. *Foxboro*

1099. Copper Alloys

64-page book on free-cutting brass, copper and bronze. *Chase Brass*

1100. Copper Nickel Alloys

8-page bulletin on composition, properties and applications of series of 12 copper-nickel-base alloys available in cast form. *Waukesha Foundry*

1101. Core Ovens

Bulletin 31 on batch-type foundry ovens for ferrous and nonferrous shops. *Despatch*

1102. Corrosion Resistance

35-page booklet on plastic materials of construction. *Atlas Mineral Products*

1103. Corrosion Resistance

32-page brochure on causes of corrosion and means of combating them. Choice of materials for condenser tubes. *Revere Copper & Brass*

1104. Cutting Metals

28-page booklet tells how to cut metals properly with hand and power hack saws and band saws. *Clemson Bros.*

1105. Cutting Off

8-page bulletin on circular saw blades for cutting off. *Motch & Merryweather*

1106. Cutting Oil

Shop notebook gives important facts on right cutting fluid for any machining operation. *D. A. Stuart*

1107. Cylinders

Bulletins A-105 and H-104 on air cylinders, low-pressure hydraulic cylinders, high pressure hydraulic cylinders. *Miller Motor*

1108. Degreasing

24-page brochure on medium-pH cleaner to follow solvent degreasing or other precleaner. *Northwest Chemical*

1109. Degreasing

Pamphlet on properties and use of trichlorethylene. *Niagara Alkali*

1110. Degreasing

34-page booklet on vapor degreasing. Design, installation, operation and maintenance of equipment. *Circo Equipment*

1111. Densitometer

Bulletin 39 on densitometer comparator as an accessory for spectrographic analysis. *Baird*

1112. Descaling Process

8-page bulletin on sodium hydride descaling process for ferrous and nonferrous metals. *Du Pont*

1113. Design of Dies

32-page bulletin on design of dies for upset forging. Also rules for upsetting and examples of forgings. *Ajax Mfg.*

1114. Die-Casting Machines

Illustrated booklet giving specifications, application data and full explanations of two new production advantages on company's line of die-casting machines. *Lake Erie Engineering*

1115. Die Casting Machines

Copies of "Lester Press" describe various features of aluminum die casting machines. *Lester-Phoenix, Inc.*

1116. Die Sets

24-page catalog on all steel die sets and supplies. *Superior Steel Products*

1117. Dilatometer

Catalog Micro 8161 on equipment for thermal analysis of metals, ceramics. *Leitz*

1118. Drawing Compounds

Folder on lubricant for forming and drawing of stainless. *Hangsterfer*

1119. Ductile Iron

4-page booklet gives characteristics, properties and comparison with other metals. *Howard Foundry*

1120. Edge Position Control

12-page Bulletin 161 on control system that continuously measures and controls edge position of moving sheet metal. *Askania*

1121. Electric Heaters

Bulletin 52 on quartz electric radiant immersion heaters. *Glo-Quartz Electric Heater Co.*

1122. Electric Heaters

16-page Catalog 53 on various types of electric heating units and controls. *Waage*

1123. Electric Melting

Bulletin 527 on compact arc furnace. Melt time and power consumption for four alloys. *Detroit Electric Furnace*

1124. Electronic Controllers

16-page Bulletin No. B226 on recording controllers for temperature, pressure, flow, liquid level and humidity. *Bristol*

1125. Electroplating

Folder on new process for electroplating intricate precision parts with precious or common metals at controlled tolerances. *American Electro Products*

1126. Enamel on Aluminum

Bulletin 2001 on application of porcelain enamels on aluminum alloys. Procedures in selection of alloys, application of enamel, correction of defects. *Pemco Corp.*

1127. Fasteners

68-page catalog of screws, bolts, nuts, washers. *Interstate Screw Corp.*

1128. Fatigue of Titanium

5-page article on fatigue characteristics of titanium and three titanium alloys. *Rem-Cru*

1129. Ferro-Alloys

64-page book describes over 50 metals and alloys produced by company. *Electro Metallurgical*

1130. Filters

8-page bulletin on dimensions and capacities of industrial filters. *Industrial Filtration Co.*

1131. Finishing

Six bulletins describing finishing compounds for stainless steel, aluminum, other metals. *Apothecaries Hall*

1132. Finishing

Catalog A-653 gives complete story on planning industrial finishing systems and shows many installations of cleaning and pickling machines. *R. C. Mahon*

1133. Finishing

28-page catalog B-9 on corrosion-resistant baskets, racks, crates and tanks and other fixtures for cleaning and finishing. *Rolock*

1134. Finishing Compounds

8-page booklet on compounds for barrel finishing. Methods of deburring, surface finishing and precision finishing. *Minnesota Mining and Mfg.*

1135. Finishing Machinery

24-page catalog on polishing, buffing, grinding and deburring equipment. *Hammond Machinery*

1136. Flaw Detection

Illustrated bulletin on Spotcheck, new dye-penetrant method for locating surface defects. *Magnaflux*

1137. Flaw Detection

12-page bulletin on location of flaws by two dye-penetrant inspection methods. *Turco Products*

1138. Flow Meter

Data Sheet 10.3-5 on electronic flow

ANACONDA METALS AT WORK



Meet the educated screw

This is a whole family of screws, known as Screwsticks, and joined head-to-toe. Insert a Screwstick in the driver, aim it at the hole—and from there on the Screwstick tightens itself to the predetermined torque, shears itself and gets its head burnished by the following screw which automatically advances itself. It's so fast that American Screw Co. of Willimantic, Conn., which uses ANACONDA Hexagon Brass Rod, refers to it as "jet propulsion".

Don't lose your grip



Once a novelty trick developed by the Chinese, the manufacture of these grips is now an industry. Made in a wide variety of styles and sizes by Economy Cable Grip Co. of Norwalk, Conn., they are used to anchor suspended electric power cables and to seize the end for pulling through ducts. The harder you pull, the tighter they grip. Needless to say, the ANACONDA Bronze Cable, Everdur* Rod and Copper Tube used in their manufacture never weaken from rust.

A fast delivery...with mustard



When baseball fans want their hot dogs, they want them fast—so Stainless Alloy Fabricators of Detroit built this "Double-Header" baseball park hot dog server. Its big capacity for hot dogs—and fast service—is its double bun warmer, one at each end, heated by copper water boilers. If the water runs dry, it's no strike-out. Boilers are made of phosphorized copper sheet with joints formed by fusing the edges with a Heliarc torch. No solder used, no seams to burn open.

How to treat a fracture



A fracture often means long uselessness—but that needn't be true of machinery. Usually braze welding can make it good as new and at a fraction of the time and cost of replacing it. This fractured cast iron conveyor drive sprocket, for example, would have taken two months to replace. The Universal Welding Co., Rochester, N. Y., repaired it in only 7 hours by braze-welding with ANACONDA-997 (Low Fuming) Bronze Welding Rod. Moral: don't count the patient out before consulting your welder.

There's more to this than meets the eye

In our Technical Department you will find a range of experience that covers the entire field of copper and copper-alloy applications in the metalworking industries. If you have a problem of metal selection, we are at your service. *The American Brass Company, Waterbury 20, Connecticut. In Canada: Anaconda American Brass Ltd., New Toronto, Ont.*

*Reg. U. S. Pat. Off. 5301

ANACONDA the name to remember in COPPER-BRASS-BRONZE

meter for liquids and gases. *Minneapolis-Honeywell*

1139. Flow Meters

Bulletin on gas flow meter for furnace installations. *Hays Corp.*

1140. Flow Meters

24-page manual on application and installation of indicating flow meter. *Meriam Instrument*

1141. Forging

Series of articles on modern forging methods. *Hill Acme*

1142. Forging Hammers

24-page brochure describes construction and use of steam drop hammers. *Erie Foundry*

1143. Forgings

Catalog GI on types of upset and hammer forgings for various applications. *Commercial Shearing & Stamping*

1144. Forgings

20-page Catalog 51 on various types of forgings, their strength and related data. Tables, drawings. *Merrill Bros.*

1145. Forging Manipulators

Folder on manipulators for automotive, ordnance, aluminum and specialty forging. *Salem-Brosius*

1146. Forming Dies

Data on roller dies for forming tubes and rolled shapes. *American Roller Die*

1147. Forming Dies

Folder on styles of forming dies for stainless heads—in wide range of sizes and gages. *Carlson*

1148. Foundry

36-page illustrated booklet dealing with foundry products, procedures and craftsmanship. *Lebanon Steel Foundry*

1149. Foundry Coatings

Data on colloidal graphite for mold washes, pattern coatings, core coatings, chill coatings. *Acheson Colloids*

1150. Foundry Ovens

Bulletin 30 on convevor-type forced convection core ovens. *Despatch*

1151. Foundry Supplies

28-page Catalog 1043C on oil and gas-burning equipment for cupola lighting, mold drying, ladle heating, core baking, furnace heating. *Hauck*

1152. Furnace Insulation

Bulletin on ceramic fiber that can give impressive savings compared with high-quality insulating brick. *Refractories Div., Carborundum Co.*

1153. Furnaces

Bulletin D on salt pot furnaces, forging furnaces, melting furnaces and others. *Eclipse*

1154. Furnaces

Bulletin 162 on high speed furnaces for forging, upsetting, extruding, stress relieving. *Surface Combustion*

1155. Furnaces

Bulletin 433 on electric, convection-type pit furnaces for air drawing, tempering, aging, annealing. *W. S. Rockwell*

1156. Furnaces

16-page booklet "Proven Heat Treating Efficiency" displays complete line of furnaces. *Loftus Eng'g.*

1157. Furnaces

Bulletin describes 18 electric furnaces for research and small-scale production, with operating temperatures to 3000° F. *Harper Electric Furnace*

1158. Furnaces

High temperature furnaces for temperatures up to 2000° F. are described in bulletin. *Carl-Mayer Corp.*

1159. Furnace Belts

44-page catalog describes metal belts for quenching, tempering, carburizing and other applications. *Ashworth Bros.*

1160. Furnaces, Heat Treating

32-page catalog on high-speed gas furnaces for heat treating carbon and alloy steels; also pot furnaces for salt and lead hardening. *Charles A. Hones*

1161. Furnaces, Heat Treating

Bulletin on furnaces for annealing, normalizing, hardening, tempering, forging. *Flinn & Dreffein Eng'g.*

1162. Furnaces, Heat Treating

12-page bulletin on conveyor furnace, radiant tube gas heated, oil or electrically heated. *Electric Furnace Co.*

1163. Furnaces, Heat Treating

Bulletin on fuel and electric furnaces for heat treating. *Dempsey*

1164. Furnaces, Heat Treating

Catalog on furnaces for tool room and general purpose heat treat. *Cooley*

1165. Furnaces, Rotary Hearth

Folder giving drawings, dimensions, capacity, Btu required for drawing, annealing, forging. *Gas Machinery*

1166. Gamma Radiography

Data file on equipment and sources for cobalt 60 radiography in industry. *Technical Operations*

1167. Gas Analysis

48-page catalog 81 on equipment and accessories for gas analysis. *Burrell*

1168. Gear Hardening

Folder on application of induction heating to high-production hardening of gears. *Westinghouse*

1169. Gold Plating

Folder on salts for bright gold plating. Also lists equipment needed. *Sel-Rex*

1170. Grainal Steel

6-page article on use of grainal as boron-additive alloy and properties of grainal steels. *Vanadium Corp.*

1171. Graphite Electrodes

Vest-pocket notebook containing 90 pages of information on electric furnace electrodes and other carbon products. *Great Lakes Carbon Corp.*

1172. Graphitic Tool Steels

48-page booklet on heat treating data, properties and 46 specific applications of graphitic tool steel. *Timken*

1173. Grinder

Catalog on hydraulic grinder and many accessories. *K. O. Lee*

1174. Grinding Samples

Bulletin on equipment for fine grinding of specimens with hand and motor powered grinders. *Buehler Ltd.*

1175. Hand Pyrometer

4-page booklet on uses for portable instrument which measures temperatures to 1500° F. *General Electric*

1176. Hard Surfacing

40-page Hard-Facing Manual tells what metals can be hardfaced, how to select right hardfacing material, lists step-by-step procedures and industrial applications. *Haynes Stellite*

1177. Hardness Numbers

Pocket-size table of Brinell hardness numbers incorporating other tabular information. *Steel City Testing*

1178. Hardness Tester

4-page bulletin on Brinell hardness tester weighing 26 lbs. for portable and stationary use. *Andrew King*

1179. Hardness Tester

Bulletin ET 439 on new portable hardness tester. *Newage International*

1180. Hardness Tester

20-page book on hardness testing by Rockwell method. *Clark Instrument*

1181. Hardness Tester

Literature on Brinell testing machines. *Detroit Testing Machine Co.*

1182. Heating Elements

24-page bulletin H on electric heating elements. Includes extensive tabular data on physical and electrical specifications for various sizes. *Globar Div. Carborundum Co.*

1183. Heat Resisting Alloy

Bulletin 1052 on properties of alloy for 1800° F. and higher. *Kennametal, Inc.*

1184. Heat Treating

Bulletin describes baskets, crates, trays, furnace parts for heat treating. *Stanwood*

1185. Heat Treating

56-page "Heat Treating Alloy Steels". *Republic Steel*

1186. Heat Treating

Handy, vest-pocket data book has 72 pages of charts, tables, diagrams and factual data on late steel specifications, heat treatments, etc. *Sunbeam*

1187. Heat Treating

Bulletin 850 on shaker-hearth furnace for bright carburizing, carbonitriding, hardening. *Hevi Duty Electric*

1188. Heat Treating

12-page bulletin on heat treating in a steam atmosphere. *Leeds & Northrup*

1189. Heat Treating Aluminum

Bulletin on furnaces for aging, annealing, heat treating and forging aluminum. *Morrison Eng'g Corp.*

1190. Heat Treating Fixtures

24-page catalog on heat and corrosion-resistant equipment for heat treating and chemical processing. 30 classifications of equipment. *Pressed Steel*

1191. Heat Treating Furnaces

Bulletin No. 120A on oil and gas fired furnaces. *Mahr*

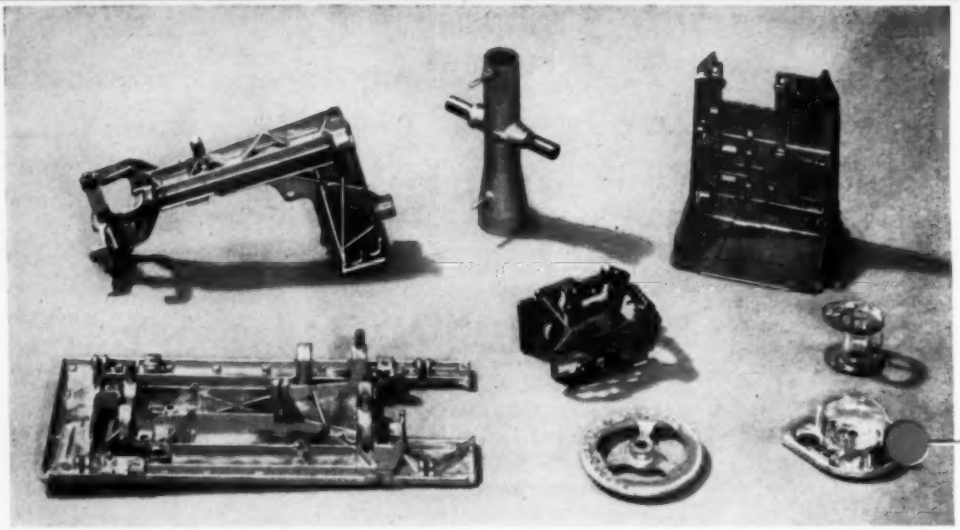
1192. Heavy Duty Cleaning

Booklet on LP cleaner for all metals except aluminum. *Cowles*

1193. Heliarc Welding

Pocket-sized folder contains current ranges and sizes for electrodes with table on current and number of passes required to weld various metals. *Linde*

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Both Progressive guns in the above illustration have the same chassis—the difference is in the interchangeable cylinders, jaw extensions, electrode adapters, and tips.

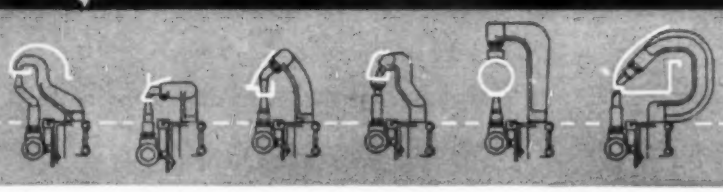
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Group of special jaw designs demonstrating wide versatility of Progressive Welding Guns.



1194. High-Alloy Castings

28-page "Ni-Cr Castings to Resist Heat & Corrosion". *Standard Alloy*

1195. High Speed Steels

Catalog of grades, applications, heat treatment of high speed steels. *Vanadium Alloys Steel*

1196. High Strength Steel

26-page booklet on properties, uses, applications of high tensile low alloy steel. *Jones & Laughlin*

1197. High-Temperature Belts

24-page bulletin on metal conveyor belts. *Wickwire Spencer*

1198. High-Tensile Steel

Bulletin on nickel-copper steel of low-alloy, high-strength type. *Youngstown Sheet and Tube*

1199. Hydrogen Atmosphere

Bulletin on equipment for supplying hydrogen with oxygen content less than one part per million and dew point to −70° F. *Baker & Co.*

1200. Identifying Alloys

Booklet of procedures for rapid identification of more than 125 metals and alloys. *International Nickel*

1201. Illium

Data on corrosion resistance, strength and workability of Illium alloy. *Illium*

1202. Impregnating Castings

8-page bulletin on impregnating porous castings. Properties of impregnant. *American Metaseal*

1203. Induction Heating

Folder on electronic heaters in a selection of frequencies. *Scientific Electric*

1204. Induction Heating

12-page bulletin 5679 on induction hardening, brazing, annealing at 1000, 3000, and 10,000 cycles. *General Electric*

1205. Induction Heating

Data folder on megacycle tube-type machines for soldering, brazing, hardening. *Sherman Industrial Electronics*

1206. Induction Heating

Review of applications of 60-cycle induction heating. *Induction Heating Devices*

1207. Induction Heating

New 36-page catalog on high frequency induction heating. *Lepel*

1208. Induction Heating

Bulletin 1440 on system for safety control of induction heating through use of components built into every unit. *Lindberg Engineering*

1209. Induction Heating

Bulletin on low-frequency (60-cycle) induction heating furnace for nonferrous metals. *Magnethermic*

1210. Induction Heating

60-page catalog tells of reduced cost and increased speed of production on hardening, brazing, annealing, forging or melting jobs. *Ohio Crankshaft*

1211. Industrial Furnaces

Book 127 on planning expansion, remodeling or modernization of plant. *Continental Industrial Engineers*

1212. Inspection

Folder on instrument for examination of interior areas or difficult-to-see surfaces. *American Cystoscope*

1213. Insulating Brick

Bulletin on fire brick and sil-o-cel insulating brick. *Johns-Manville*

1214. Investment Casting

10-page bulletin or precision casting method, advantages and problems of method. *Howard Foundry*

1215. Investment Castings

Production techniques, design, accuracy, advantage of investment casting. *Arwood Precision Casting*

1216. Iron 99.84% Pure

Data on composition and price of electrolytic iron melting stock 99.84% pure. *Plastic Metals Div., National Radiator*

1217. Laboratory Equipment

Booklet on mobile laboratories and variety of equipment available. *Fisher Scientific*

1218. Laboratory Equipment

"Laboratory Spotlight" catalogs laboratory ovens, colorimeters, balances, microscopes. *Harshaw*

1219. Laboratory Furnaces

Data sheets on complete line of laboratory furnaces for metallurgical operations. *Boder Scientific*

1220. Low-Carbon Stainless

New bulletin, "Melting Low-Carbon Stainless Steel", shows advantages in use of new low-carbon chromium alloy for producing extra-low-carbon grades. *Electro Metallurgical*

Among a Tool Steel Salesman's Souvenirs . . . .



a punch and a slug—not an unusual punch but one with a history of accomplishment.

A good customer, during the hectic days of World War II, had difficulty getting a 1¾" diameter hole in about 2000 pieces of hot rolled plate 1¼"x 8"x 8" in a hurry. The finished product was a hook-eye to be welded atop buoys, on a Navy job. Burning and drilling were tried but were too slow. With great apprehension a punch and die were made, using Ziv's PLANCHER Tool Steel. The 2000 holes were promptly punched, cold, without a hitch, and both punch and die were good for a good many more.

While you may not be punching 1¼" thick hot rolled plate, you may have other jobs calling for a tough, resilient tool steel, built to be tough, real tough, then it is wise to use Ziv's PLANCHER Silicon Manganese Tool Steel.



Photo Courtesy of Mesker Bros. Iron Co. St. Louis, Mo.

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1221. Lubricant

8-page folder describes use of molybdenum disulfide lubricant in cold forming, cold heading and other applications. Case histories. *The Alpha Corp.*

1222. Lubricant

New literature on anti-seize molybdenum disulfide lubricant. *Bel-Ray*

1223. Lubricants

4-page booklet on colloidal graphite, molybdenum disulfide, vermiculite and zinc oxide dispersions for industry. *Acheson Colloids*

1224. Machining Costs

12-page "Relation of Machining Time to Material Cost". Comparative machinability costs per ton for eleven steels. *La Salle Steel*

1225. Magnesium

Dimensions, analyses, property data of magnesium plate and sheet. *Brooks & Perkins*

1226. Magnesium

4-page pamphlet on characteristics and properties of various magnesium alloys. *Howard Foundry*

1227. Magnesium

42-page booklet on wrought forms of magnesium. Includes 31 tables. *White Metal Rolling & Stamping*

1228. Magnesium Welding

Reprint describes an investigation to evaluate inert-gas-shielded metal-arc welding of magnesium. *Air Reduction*

1229. Martempering

Article gives case histories on martempering of aircraft gears. *Ajax Electric*

1230. Meehanite Gears

Characteristics of Meehanite which make it good gear material, design of gears, applications. *Meehanite Metal Corp.*

1231. Melting

24-page book on electric furnaces for steel mills and foundries. Table of types, sizes, ratings. *American Bridge*

1232. Melting Aluminum

Folder A-5 describes automatic melting and pouring unit for production of aluminum die castings. *Ajax Eng'g.*

1233. Metal Analysis

Brochure on Quantometer, which furnishes pen-and-ink records of quantitative spectrochemical analyses with extra copies. *Applied Research Labs.*

1234. Metal Cutting

64-page catalog No. 29 gives prices and describes complete line of rotary files, burrs, metalworking saws and other products. *Martindale Electric*

1235. Metal Hose

48-page Catalog 200 has section on engineering data, including friction losses versus flow rates; also burst pressures and working pressures. *Titeflex*

1236. Metallograph

Bulletin on camera microscope and metallograph. *United Scientific*

1237. Metallograph

20-page book on desk-type metallograph. *American Optical*

1238. Metallograph

Metallograph, described in catalog E-240, furnishes four different accurate images of same sample for complete identification with bright field, dark field or polarized light. *Bausch & Lomb*

1239. Micrographic Supplies

6-page bulletin on a universal camera microscope giving plate magnifications from 4 to 3000 ×. Full details on optics and accessories included. *Opplem Co.*

1240. Microhardness Tester

Bulletin DH-114 on Tukon hardness testers in research and industrial testing. *Wilson Mechanical Instrument*

1241. Microhardness Tester

Bulletin describes the Kentron microhardness tester. *Kent Cliff Laboratories*

1242. Modulus Determination

Data sheet on equipment for determination of modulus of elasticity by sonic method that measures resonance frequency of masses weighing up to 1500 lb. *Electro Products Laboratories*

1243. Moly-Sulphide Lubricant

40-page booklet on Moly-sulphide lubricant gives case histories for 154 different uses. *Climax Molybdenum*

1244. Nitriding Furnace

Bulletin 646R on carburizing and nitriding furnace giving atmosphere circulation to 1850° F. *Hevi Duty*

1245. Nitrogen Atmosphere

Bulletin on generator for producing pure nitrogen with a controllable hydrogen content. *Baker & Co.*

1246. Nondestructive Testing

Data on equipment for inspection and sorting. *Magnetic Analysis*

1247. Nondestructive Testing

Series of bulletins gives data on both ultrasonic and magnetic testing instruments. Illustrated. *J. W. Dice Co.*

1248. Nonferrous Melting

12-page bulletin on eight types of gas furnaces for melting nonferrous metals. *Bellevue Industrial Furnace*

1249. Nonferrous Metals

"Metal of the Month" letters include market trends, statistics, helpful data. *Belmont Smelting & Refining*

1250. Oil Quenching

8-page brochure tells in detail how carbon steel often can replace alloy steel when additive is used in the quenching oil. *Aldridge Industrial Oils*

1251. One-Minute X-Ray

Reprints on Land-Polaroid method of X-ray film processing. *Picker X-Ray*

1252. Ornamental Metal

Folder shows designs of perforated metals and lists applications. *Accurate Perforating Co.*

1253. Peening

Bulletin on use of cut wire shot for peening and cleaning. *Park Chemical*

1254. Phase Contrast

16-page Bulletin D-104 on theory, applications and equipment for phase contrast microscopy. *Bausch & Lomb*

1255. Pickling Baskets

Data on baskets for degreasing, pickling, anodizing and plating. *Jelliff*

1256. Pickling Baskets

12-page bulletin on mechanical picklers, crates, baskets, chain and accessories. *Youngstown Welding & Eng'g.*

1257. Pickling Inhibitor

4-page folder on pickling inhibitor. Functions and advantages. *Houghton*

1258. Pipe and Tubing

New 68-page book is a practical treatise on pipe and tube making, answering many pertinent questions on tube mill operations and production. *Yoder Co.*

1259. Plating

8-page booklet on plating rack designed to make spline section or body of rack a permanent tool. *National Rack*

1260. Plating

Set of bulletins on filtration equipment for plating solutions. *Sparkler*

1261. Plating Anodes

8-page catalog on sizes, shapes, compositions of copper, lead, zinc, tin, cadmium anodes. *Federated Metals*

1262. Plating Rectifiers

Bulletin ER-105 on rectifiers designed for metal finishing. *Hanson-Van Winkle-Munning*

1263. Plating Solutions

Bulletin 12 on electric heating of pickling and plating solutions. *Pyrosil*

1264. Polishing Machines

6-page bulletin on vertical horizontal machines for buffing and polishing. *Central Machine Works*

1265. Polishing Materials

20-page booklet includes samples of emery, aluminum oxide and silicon carbide papers and 12 polishing cloths. *Buehler Ltd.*

1266. Portable Hardness Tester

20-page bulletin on use of portable hardness testers and accessories. *Ames Precision Machine*

1267. Potentiometer

Bulletin 1210 on direct-reading portable potentiometer. *Minneapolis-Honeywell*

1268. Powder Metallurgy

32-page handbook gives 24 case histories of parts designed or redesigned for powder metal production. Cost comparisons; definitions of terms and list of standards. *New Jersey Zinc*

1269. Powdered Metals

Bulletin 3101 on compacting press for powdered metals, ceramics and plastics. *Baldwin-Lima-Hamilton*

1270. Precision Casting

Booklet on ferrous and nonferrous castings made by the lost-wax process. *Cadmet*

1271. Precision Casting

Bulletin on mechanically-operated induction furnace for precision casting. *Ajax Electrothermic*

1272. Precision Casting

44-page Catalog 53 covers every stage of the investment casting process. *Alexander Saunders*

1273. Precision Forgings

Data folder on small metal parts forged to within a few thousandths. *Utica Drop Forge*

1274. Pressure, Vacuum Gages

32-page Catalog 7001 on gages for vacuums to 10^{-11} mm. Hg and pressures to 150,000 psi. *Minneapolis-Honeywell*

1275. Production Heating

Bulletin 511 on gas heating equipment for brazing and annealing. *Gas Appliance Service*

1276. Proportioner

Bulletin 630 proportioner, a relay-controlled, air-operated atmospheric regulator to proportion large quantities of low-pressure gas and air for combustion. *North American Mfg.*

1277. Protecting Aluminum

Folder on Alodine for protection of painted or unpainted aluminum. *American Chemical Paint*

1278. Pyrometer Supplies

Buyers' Guide for pyrometer supplies, No. 100-5. *Minneapolis-Honeywell*

1279. Pyrometers

New 24-page thermocouple and accessory bulletin. *West Instrument*

1280. Quenching

Article in "Heat Treat Review" compares hot oil and molten salt quenching. *Surface Combustion Corp.*

1281. Quenching

Data sheet on mixer for agitation of quenching liquids. *Chemineer*

1282. Quenching

Bulletin 120 on use of heat exchangers to provide heat control in quenching bath. *Niagara Blower*

1283. Quenching

"Handbook on Quenching" gives complete information. *E. F. Houghton*

1284. Radiation Detector

Folder on radiation detector, full-scale range 250 mr., which operates without batteries. *Consolidated Eng'g.*

1285. Rare Earths

Progress Report Number 1, "Rare Earths in Melting." *Molybdenum Corp.*

1286. Refractory Mixes

16-page bulletin 315 on properties and applications of sillimanite super-refractory ramming mixes and furnace patches. *Chas. Taylor Sons*

1287. Resistance Testing

Bulletin 100 on production tester for measuring electrical resistance. *Rubicon*

1288. Resistance Welding

24-page catalog on equipment for resistance welding includes reference tables and property and application charts. *Ampco.*

1289. Rhodium Plating

Rhodium plating as replacement for usual plating metals. *Baker & Co.*

1290. Rivet Setting

Operating instruction manual includes detailed information on the operation of automatic rivet-setting machines. *Milford Rivet & Machine Co.*

1291. Roll Formed Shapes

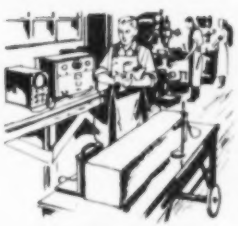
24-page Bulletin 1053 on designing, forming and producing shapes from ferrous and nonferrous metals. *Roll Formed Products Co.*

(*Continued on p. 32-A*)

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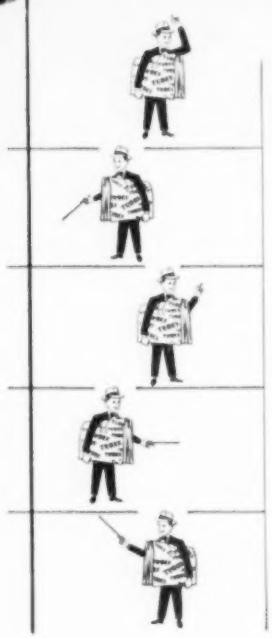
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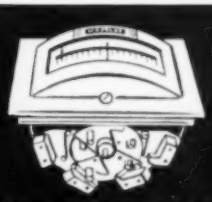
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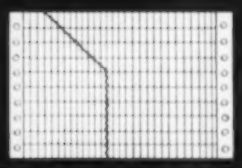
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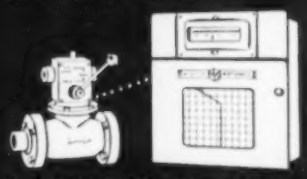
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(Continued from p. 31)

1292. Rolling Mills

Folder on 3x5 in. flat and wire mills. *Stanat Mfg.*

1293. Rust Preventives

12-page bulletin on water-soluble rust-preventive. *Production Specialties*

1294. Rustproofing

Folder on acid-proof coatings for metal finishing and chemical and metallurgical plant maintenance. *Electro Chemical Engineering*

1295. Rustproofing

Data sheet on slightly alkaline compound NR-31 for rustproofing iron and steel. *Enthone*

1296. Salt Bath Furnaces

Data on salt bath furnaces for batch and conveyorized work. *Upton*

1297. Salt Baths

Technical bulletin describes Neutra-Gas process, a method of maintaining neutrality in chloride-base salt baths. *Park Chemical Co.*

1298. Salt Baths

28-page book deals with heat treatment, carburizing, bath maintenance, safety precautions. *American Cyanamid*

1299. Salt Baths

75-page manual on salt baths for case hardening and heat treating. *DuPont*

1300. Salt Baths

Bulletin H-1 on neutral salt baths and their operation. *Park Chemical*

1301. Saws

Catalog C-53 describes 35 models of metal-cutting saws. *Armstrong-Blum*

1302. Screw Thread Inserts

16-page book of design data and specifications on screw thread bushings of helically coiled wire, for aluminum, magnesium, iron, steel. *Heli-Coil Corp.*

1303. Shearing

16-page catalog on pivoted-blade shears for cutting metal up to 1.25 in. thick. *Cleveland Crane & Engineering*

1304. Sheet Separation

Data on magnetic device for automatic separation of stacked steel sheets. *Basco Mfg.*

1305. Shot and Grit

Handy calculator has size data for SAE grades of shot and grit. *Pangborn*

1306. Shot Peening

Selection and use of shot and grit for peening. *Cleveland Metal Abrasive*

1307. Shotblasting

16-page "Primer on the Use of Shot and Grit". Problems of blast cleaning operations. *Hickman, Williams*

1308. Silicon Bronze

Article on silicon bronze from "Lavingot Technical Journal". *Lavin*

1309. Silver Brazing

Series of eight technical bulletins on silver brazing. Joint strength, design, stress analysis, heat treatment, fluxes. *Handy & Harman*

1310. Solder

Data on cored solder which may be used on stainless steel and nickel alloys. *Alpha Metals*

1311. Soldering Aluminum

6-page folder on use of a noncorrosive flux for soldering aluminum. Data on joint strength and ductility. *Insulation and Wires, Inc.*

1312. Sonic Thickness Tester

Measurement of wall thickness from one side by sonic method. *Branson*

1313. Spark Testing

20-page spark test guide features spark diagrams of 13 standard tool and die steels. *Carpenter Steel*

1314. Specifications Index

28-page cross index lists copper alloy specifications of nine different Government agencies. *American Brass*

1315. Spectograph

16-page catalog G2-53 describes grating spectrographs for precision analysis. *Jarrell-Ash*

1316. Spray Painting

16-page bulletin on electrostatic process for spray painting. Seven case histories. *Ransburg Electro-Coating*

1317. Spring Steels

Spring steel catalog offers 785 sizes of hardened and tempered spring steels, and 133 cold-rolled and bright annealed s in stock. *Sandvik Steel*

1318. Springs

Data on compression, torsion, flat, tension, and special springs. *Evans*

1319. Stainless Bars

28-page technical book on stainless bars includes processing informa about cutting, welding, forging, upset machining, and heat treating. *Allegh Ludlum*

1320. Stainless Castings

8-page bulletin gives recommenda charts for type of stainless to use in v ous corrosive solutions, under var conditions. *Waukesha Foundry*

1321. Stainless Fastenings

20-page catalog of stainless steel screws, nuts, washers, machine scr sheet metal screws, set screws, pipe ting and specialties. *Star Stainless S*

1322. Stainless Steel

16-page "Type 430 Stainless for A tects & Designers". *Washington Steel*

1323. Stainless Steel

Bulletin gives example of five type stainless steel castings. *Sivyer*

1324. Stainless Steel

Data sheet on wrought alloy type 35% Ni—15% Cr. Mechanical prope of bars to 1800 F; design stresses to F. *Rolled Alloys*

1325. Stainless Steel

32-page book on corrosion resistan stainless steels. 18 tables on tests in neutral and alkaline solutions. *Inte tional Nickel*

1326. Stainless Steel

Slide chart. Set top at a certain f cating operation, bottom shows ratin each standard grade. On reverse heat treating and corrosion data given. *Carpenter Steel*

1327. Stainless Tubing

6-page reprint "Tips on Stainless Aircraft Hydraulics". Design and fab tion. *Superior Tube*

1328. Stainless Tubing

8-page bulletin on corrosion-resi tubing and fabricated piping. *Youngs Welding & Engineering*

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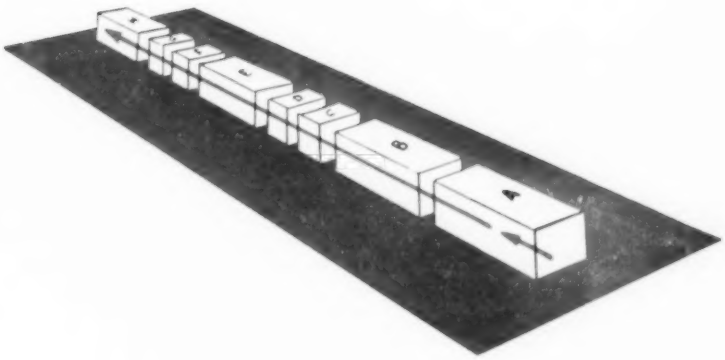
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C Quench tank and elevator
D Wash and dry
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G Wash and dry
H Draw furnace

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Four furnaces were placed in line. All production was carburized in the first. Part of the work, then, proceeded through the next three furnaces for refining, hardening and drawing. Another portion by-passes the refining operation and is hardened and drawn. The rest of the production is hardened in the second furnace, drawn at high temperatures in the third, and bypasses the fourth.

This is typical of the economies Holcroft produces for its clients. It's how one manufacturer found that Holcroft furnaces—*individually designed for the specific job*—will produce large volume heat treating at a low-cost-per-heat-treated-piece. Holcroft & Company, 6545 Epworth, Detroit 10, Michigan.

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1329. Steel Plate

32-page catalog 1243 on steel plate for carburizing, heat treating and welding. Many uses illustrated. *W. J. Holliday*

1330. Steel Tubing

Booklet on seamless and welded tubing and facilities for special tube forms. *Ohio Seamless Tube*

1331. Strain Gages

Article on fatigue life of SR-4 strain gages, in Testing Topics. *Baldwin-Lima-Hamilton*

1332. Subzero Treatment

12-page bulletin on subzero treatment of tool steel and increase in tool life resulting. *Sub-Zero Products*

1333. Super High Speed Steel

Folder on molybdenum, 8% cobalt high speed steel for use at speeds 20 to 25% greater than with ordinary high speed steel. Heat treatments, protective coatings and uses. *Firth Sterling*

1334. Surface Temperatures

Pyrocon bulletin on hand-held thermocouple-type instrument for measuring and indicating surface temperatures at exact locations. *Illinois Testing Labs.*

1335. Temperature Control

Catalog of pyrometer supplies gives data on thermocouples, protection tubes, other accessories. *Arklay S. Richards*

1336. Temperature Control

Data sheet and bulletin on controller for processing equipment. *Foxboro*

1337. Temperature Control

Bulletin 50H describes thermocouple pyrometer controller. *Thermo Electric*

1338. Tempering

Reprint of article on controlled atmosphere tempering. *Ipsen*

1339. Testing

Bulletin on test units to combine temperature range from +185 to −100° F., relative humidity from 20 to 95%, and altitude simulation from atmospheric to 80,000 ft. *Bowser*

1340. Testing Machines

32-page catalog on hydraulic testing machines. 10 models described; also accessories. *Riehle*

1341. Textured Stainless

Folder on stainless to conserve alloys and reduce weight. *Rigidized Metals*

1342. Thermocouple Data

42-page Bulletin TC-9 on thermocouples, radiation detectors, resistance bulbs, accessories. *Wheelco*

1343. Tin

Monthly newsletter, "Tin News", gives information about prices, supply, demand. *Malayan Tin Bureau*

1344. Titanium

30-page data book on properties of commercially pure and alloy titanium, melting, forging and rolling. *Republic*

1345. Tool Heat Treating

Information on "Sure-Wear" process for heat treating high-speed cutting tools. *LR Heat Treating Co.*

1346. Tool Steel

Catalog of "Pure-Ore" tool and die steel. *Kloster*

1347. Tool Steel

Folder on high carbon, high vanadium tungsten base high speed steel. *Latrobe*

1348. Tool Steel Failures

124-page book, "Tool Steel Trouble Shooter", analyzes 107 tool failures and assigns causes as among tool design faults, tool steel faults, improper heat treatment, mechanical and operational factors. *Bethlehem Steel*

1349. Tool Steel Selector

Selector is handy chart featuring general and heat treating data on non-deforming, water hardening, shock-resistant, hot work, high speed tool and hollow die steels. *A. Milne & Co.*

1350. Tubing Failures

46-page book on tube life in high-pressure high-temperature applications. Results of a great number of investigations of failures. *Babcock & Wilcox*

1351. Tumbling Barrels

10-page catalog B-8 gives specifications, applications of six types of tumbling barrels. *Globe Stamping Div.*

1352. Tungsten Electrodes

Wall chart gives data for inert-gas arc-welding of aluminum, magnesium, stainless steel with pure and thoriated tungsten electrodes. *Sylvania*

1353. Ultrasonic Inspection

Set of application sheets, each describing a specific use for ultrasonic inspection. *Sperry Products*

1354. Vacuum Finishing

Use of vacuum metallizing in manufacture of plastic and metal parts. *National Research Corp.*

1355. Vacuum Metallizing

Bulletin on equipment for industrial vacuum metallizing. *Optical Film Eng'g.*

1356. Vacuum Pumps

24-page Bulletin V51 on high-vacuum pumps and accessories. *Kinney Mfg.*

1357. Welding Electrodes

Application chart for stainless alloy and nonferrous electrodes. *Weldwire*

1358. Welding Equipment

Catalog on Cadwell process and arc-welding accessories. *Erico Products*

1359. Welding Rods

6-page bulletin on bronze welding rods. Table gives ASTM, AWS and Government specifications. *Titan Metal*

1360. Welding Steel

Booklet on "ABC's of Welding High Tensile Steel." *Arcos*

1361. Wire Baskets

84-page book on fabricated baskets for dipping and heat treating. *Cambridge Wire Cloth*

1362. Wire Straightening

Bulletin 52-C describes precision machine for straightening small wire with extreme accuracy. Applies to round wire 0.007 to 0.125 in. diameter of ferrous or nonferrous metal. *Medart Co.*

1363. X-Ray Diffraction

Analytical applications of X-ray diffraction using direct measurement techniques. *X-Ray Dept., G.E.*

1364. X-Ray Supplies

50-page catalog of industrial X-ray supplies and accessories. *Westinghouse*

October, 1953

966	996	1026	1056	1086	1116	1146	1176	1206	1236	1266	1296	1326	1356
967	997	1027	1057	1087	1117	1147	1177	1207	1237	1267	1297	1327	1357
968	998	1028	1058	1088	1118	1148	1178	1208	1238	1268	1298	1328	1358
969	999	1029	1059	1089	1119	1149	1179	1209	1239	1269	1299	1329	1359
970	1000	1030	1060	1090	1120	1150	1180	1210	1240	1270	1300	1330	1360
971	1001	1031	1061	1091	1121	1151	1181	1211	1241	1271	1301	1331	1361
972	1002	1032	1062	1092	1122	1152	1182	1212	1242	1272	1302	1332	1362
973	1003	1033	1063	1093	1123	1153	1183	1213	1243	1273	1303	1333	1363
974	1004	1034	1064	1094	1124	1154	1184	1214	1244	1274	1304	1334	1364
975	1005	1035	1065	1095	1125	1155	1185	1215	1245	1275	1305	1335	
976	1006	1036	1066	1096	1126	1156	1186	1216	1246	1276	1306	1336	
977	1007	1037	1067	1097	1127	1157	1187	1217	1247	1277	1307	1337	
978	1008	1038	1068	1098	1128	1158	1188	1218	1248	1278	1308	1338	
979	1009	1039	1069	1099	1129	1159	1189	1219	1249	1279	1309	1339	
980	1010	1040	1070	1100	1130	1160	1190	1220	1250	1280	1310	1340	
981	1011	1041	1071	1101	1131	1161	1191	1221	1251	1281	1311	1341	
982	1012	1042	1072	1102	1132	1162	1192	1222	1252	1282	1312	1342	
983	1013	1043	1073	1103	1133	1163	1193	1223	1253	1283	1313	1343	
984	1014	1044	1074	1104	1134	1164	1194	1224	1254	1284	1314	1344	
985	1015	1045	1075	1105	1135	1165	1195	1225	1255	1285	1315	1345	
986	1016	1046	1076	1106	1136	1166	1196	1226	1256	1286	1316	1346	
987	1017	1047	1077	1107	1137	1167	1197	1227	1257	1287	1317	1347	
988	1018	1048	1078	1108	1138	1168	1198	1228	1258	1288	1318	1348	
989	1019	1049	1079	1109	1139	1169	1199	1229	1259	1289	1319	1349	
990	1020	1050	1080	1110	1140	1170	1200	1230	1260	1290	1320	1350	
991	1021	1051	1081	1111	1141	1171	1201	1231	1261	1291	1321	1351	
992	1022	1052	1082	1112	1142	1172	1202	1232	1262	1292	1322	1352	
993	1023	1053	1083	1113	1143	1173	1203	1233	1263	1293	1323	1353	
994	1024	1054	1084	1114	1144	1174	1204	1234	1264	1294	1324	1354	
995	1025	1055	1085	1115	1145	1175	1205	1235	1265	1295	1325	1355	

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and now—we are moving our New York district sales office to a new office and warehouse at Hillside, New Jersey. Just south of Newark, this location is ideally suited to serve our many customers in northern New Jersey, greater New York and the Hudson River valley.

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GENEVA PARIS BRUSSELS ROTTERDAM MILAN



is setting records for lining life in high-frequency induction furnaces

INDIANA
Using Taylor Zircon grog-type ramming mix, an operator of two, 300-lb. Ajax-Northrup furnaces consistently obtains 100 heats melting nickel-chrome alloy or stainless steel. Magnesia linings averaged 20-25 heats.

SOUTH CAROLINA
Foundry superintendent writes his Taylor Zircon lining cost 0.0005 *cents per pound* after tapping 100th heat—116,650 lbs. total—of cast iron from 1000-lb. Ajax-Northrup furnace. Anticipates getting 200,000 lbs. total melt before relining. Formerly averaged 35-50 heats.

NEW YORK
Steel company obtained 324 heats from Taylor Zircon lining in 700-lb. Ajax-Northrup furnace melting stainless and a wide variety of alloy steels. A new record for this foundry!

These performance reports are being duplicated by many foundries across the nation. Linings of Taylor Zircon Ramming Mix are outperforming linings rammed of magnesia, magnesia-alumina spinel and/or sillimanite or mullite in Ajax-Northrup, Allis-Chalmers and other types of high-frequency induction furnaces melting nickel, stainless steel and similar high nickel-chrome alloys. CAUTION—Taylor Zircon linings are *not* recommended when a large percent of dirty scrap or appreciable amounts of iron oxide are present in the melt.

Write us for recommendations on your melting requirements.

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A SUBSIDIARY OF NATIONAL LEAD COMPANY
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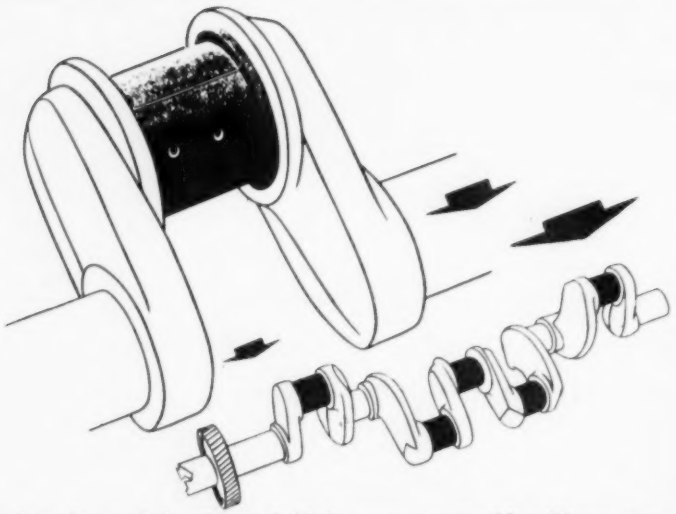
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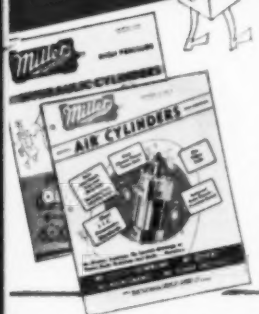


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TESTS on vacuum-cast metals show improved fatigue and stress properties. The extraordinary cleanliness and freedom from gases of Ferrovac 4340 are illustrated in the photomicrographs above.

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Commercial quantities of vacuum-melted metals are now being produced in Vacuum Metals Corporation's new expanded facilities. On order Vacuum Metals will supply test or commercial quantities of vacuum-cast metals to customer specifications.

VACUUM-MELTED METALS AVAILABLE FROM VMC:

FERROVAC® 52100
An inclusion free, high fatigue chromium-carbon steel.

FERROVAC® 440C
An inclusion free, chromium-carbon stainless steel.

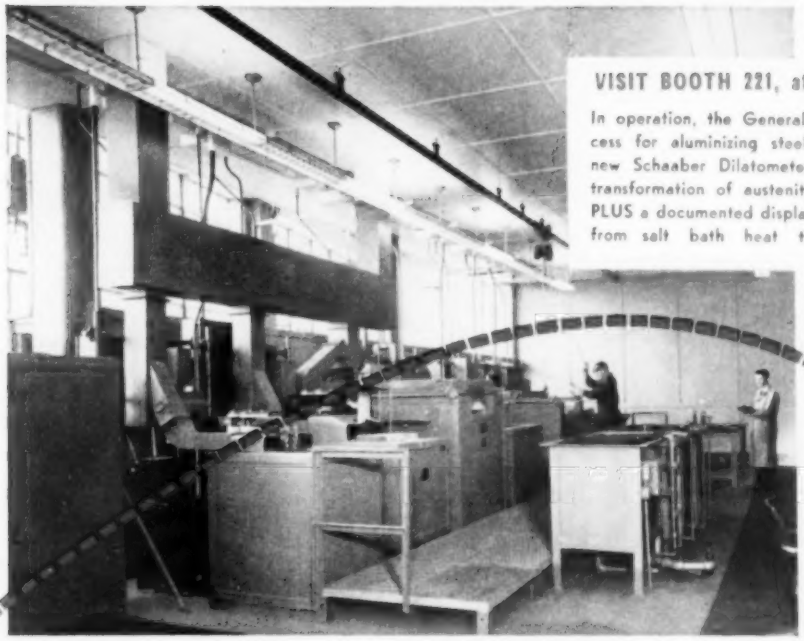
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Subsidiary of National Research Corporation
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VISIT BOOTH 221, at the Metal Show

In operation, the General Motors ALDIP process for aluminizing steel products; also the new Schaaber Dilatometer for measuring the transformation of austenite in salt baths . . . PLUS a documented display of production parts from salt bath heat treating installations.

Say Goodbye to Guesswork

ON HEAT TREATING RESULTS AND COSTS!

Without charge or obligation, the Ajax Metallurgical Service Laboratory will treat specimen parts by any of the following processes:

ALUMINIZING
CARBURIZING
CYANIDE HARDENING
NEUTRAL HARDENING
ANNEALING OR HARDENING STAINLESS STEEL
BRAZING
HARDENING HIGH SPEED STEEL
AUSTEMPERING
MARTEMPERING
PROCESS ANNEALING
CYCLIC ANNEALING
SOLUTION HEAT TREATMENT
DRAWING (Tempering)
DESCALING, CLEANING
DESANDING

What about the quality of the finished work? Will it be scale-free, devoid of decarb? Will the heat treatment prevent distortion and thereby reduce or eliminate costly grinding or finish machining operations? How much production will the furnace give per hour, and what floor space will be needed? What will the power, labor, maintenance and other heat treating costs amount to? *In short, will your proposed new furnace live up to the manufacturer's enthusiastic claims for it?*

You can be absolutely sure on all of these points before you buy an Ajax Electric Salt Bath Furnace for these reasons:

1—No Ajax salt bath furnace is ever sold until Ajax engineers—backed with experience in over 4,000 installations—are convinced it will do the job to your entire satisfaction as well as to theirs.

2—Before buying, we strongly urge that you utilize the facilities of the full commercial scale Ajax Metallurgical Service Laboratory. Send or bring batch lots of your materials for heat treating under actual working conditions. Let us prove beyond any question of doubt what can be done, how it can be done, and under exactly what conditions.

3—Once your furnace is installed, an Ajax engineer will visit your plant to double check, to instruct, and to make sure that on-the-job operation fully matches your expectations.

This policy has resulted in the most outstanding patronage ever accorded any heat treating furnace, both as to the importance and number of users. A list of users is available on request. The high percentage of customers who have re-ordered Ajax heat treating equipment is unparalleled in the furnace industry.

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AJAX ELECTRIC SALT BATH FURNACES

one minute

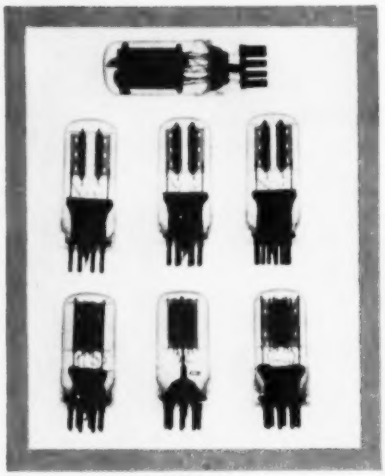
is all it takes to get finished, dry radiographs

* NOTE: Reduction to 1/5 size, combined with image decay incident to the printing process, seriously degrades in these miniature reproductions the fine detail of the 10" x 10" originals.



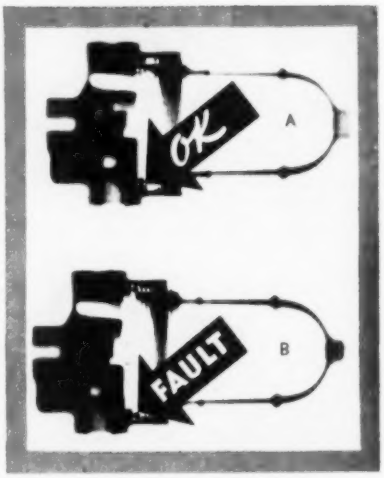
Subject: **IGNITION CABLE ELBOW**
(Ignition cable elbows filled with insulating sealing compound.)
Objective: To confirm winding spacing alignment of center wire.
Disclosed: Gas bubbles in elbows where compound failed to fill.

like



Subject: **ELECTRONIC TUBES**
Objective: To confirm alignment and spacing of elements.
Disclosed: All elements correctly oriented.

these*



Subject: **CAST ALUMINUM GASOLINE FILTER**
Objective: To confirm correct placement of gasket after completion of assembly.
Disclosed: (A) Correct assembly (B) Fractured gasket slipped out of place.

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the "rightaway" radiograph

Make the exposure and get the finished, dry radiograph a minute later . . . right where you are, in *broad daylight,* if need be. Because the Polaroid x-ray packet processes itself, you don't need a darkroom, or tanks of solutions, or dryers, or even an illuminator to view it. All you need is your source of x-rays, a supply of packets, and the compact processor unit which automatically delivers the finished radiograph.

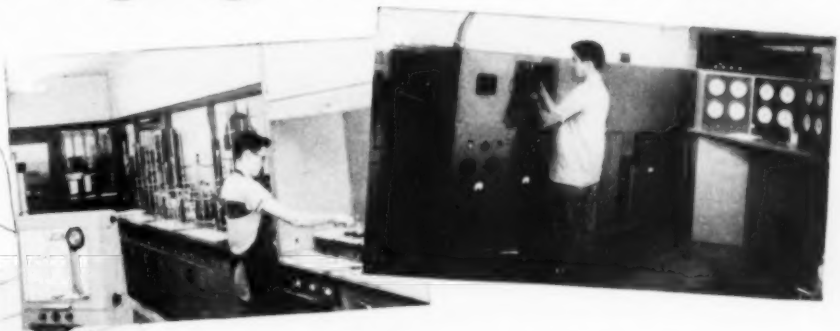
Maybe there's a place for this quick x-ray inspection method somewhere in your operation. Ask your local Picker office to help you explore your problem, or write

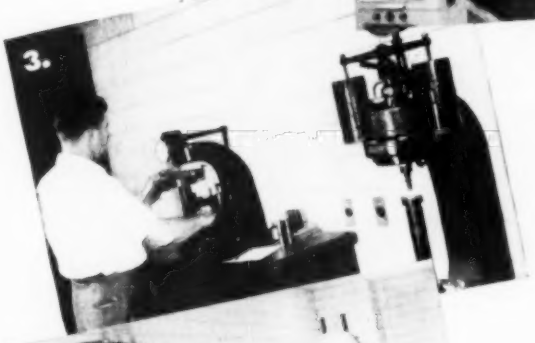
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Picker x-ray POLAROID

Final exams for Finkl's Forgings and Die Blocks









From steel formula to finished product, Finkl die blocks and forgings are carefully checked. Analyzed spectroscopically and chemically, tested with Rockwell and Brinnell, and thoroughly inspected by Ultrasonic and Magnaflux methods, Finkl forgings and die blocks are the finest available and at the lowest cost to you.

These tests are run under the keen metallurgical eye of Ted and his crew of technicians, John, Clay, Oscar, and Kenny, assuring you that your forgings and die blocks have passed the most critical modern tests by experts in their field.

Since 1879, "Forgings by Finkl" and die blocks with "Impressions That Last" have been products of the highest quality. When planning your die block or forging requirements, you are invited to call on Finkl's experienced men and modern facilities.





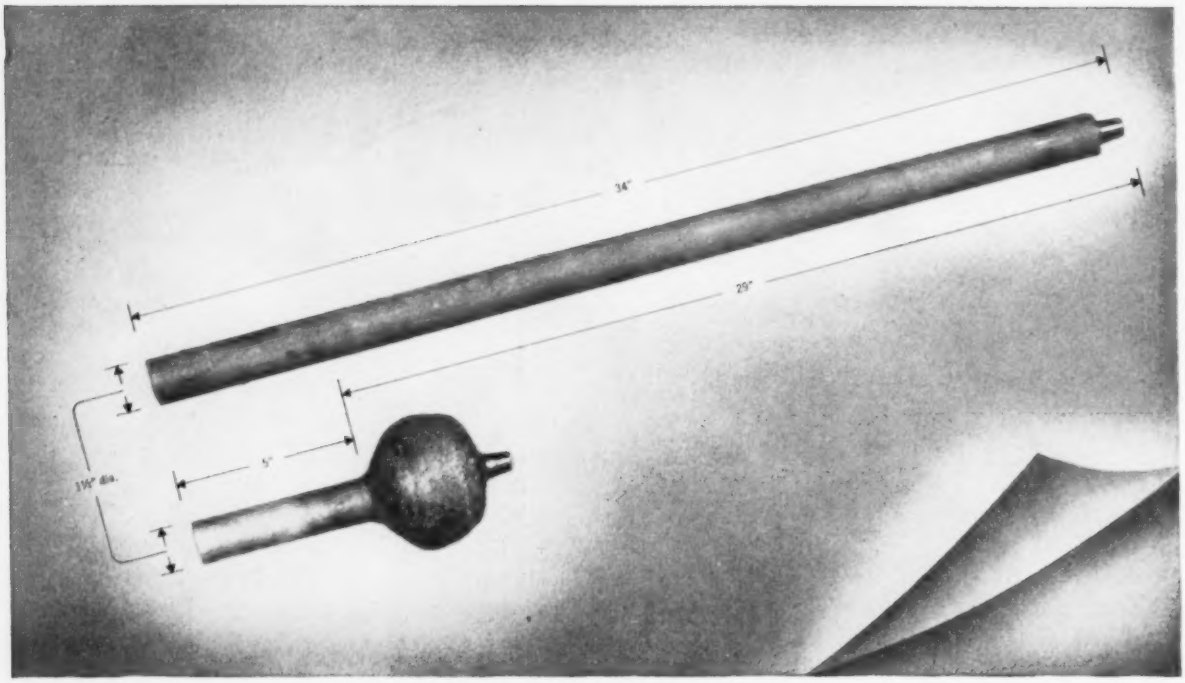
1. Spectroscopic test
2. Chemical test
3. Hardness test
4. Tensile test
5. Ultrasonic test
6. Magnaflux test

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FORGINGS • DIE BLOCKS • ELECTRIC FURNACE STEELS



UPSETTING some old ideas as to the size of UPSETS!

Any good forging handbook will tell you that unsupported steel can be upset only three diameters. But today's new forging techniques at UTICA have revised that. As example, 29" of this Inconel X 1½" bar were upset into the bulb on the end. This bulb, after precise forging and finishing, will become a very high speed turbine wheel with integral shaft.

UTICA electrical upsetting gives special advantages

Today both old and tough *"new"* metals are being upset—on a production basis—in UTICA'S battery of upsetting machines. Many special forging advantages result—and unique product design gains too. Primarily the upsetting brings greater strength and ruggedness through controlled grain flow. It also makes new designs possible—designs previously impractical. Most important of all, it drastically reduces not only material costs but machining time and costs as well.

A product of the UTICA "Quality First" program

This is just one development in the long range UTICA program—which combines new methods and new machines to mass produce quality forgings...accurate to a very few thousandths... many produced from the *"new"* hard-to-handle metals. Today UTICA production covers jet blades and other defense items—perhaps tomorrow we can serve you with some of the great forging advances developed during the past few years.

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die steels *for* hot work

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4% Cr — 1% C

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9.50% W — 3.50% Cr

HOTPRESS
9.50% W — 2% Cr

WW HOTWORK
12% W — 12% Cr

FORGE-DIE
.26% C — 14% W

SC SPECIAL
.41% C — 14% W

RED CUT SUPERIOR
("J" TEMPER)
.50% C — 18% W

VAN-LOM
.60% C — 8.25% Mo

These Die Steels are designed to meet your every hot work requirement. They are made to exacting standards and inspected by magnaflux, reflectoscope and deep etching to insure First Quality Steels. All grades are available in bars and forgings.

Our sales representatives will be glad to work with you in selecting the best grade for your particular job and in the correct heat treatment for maximum performance.

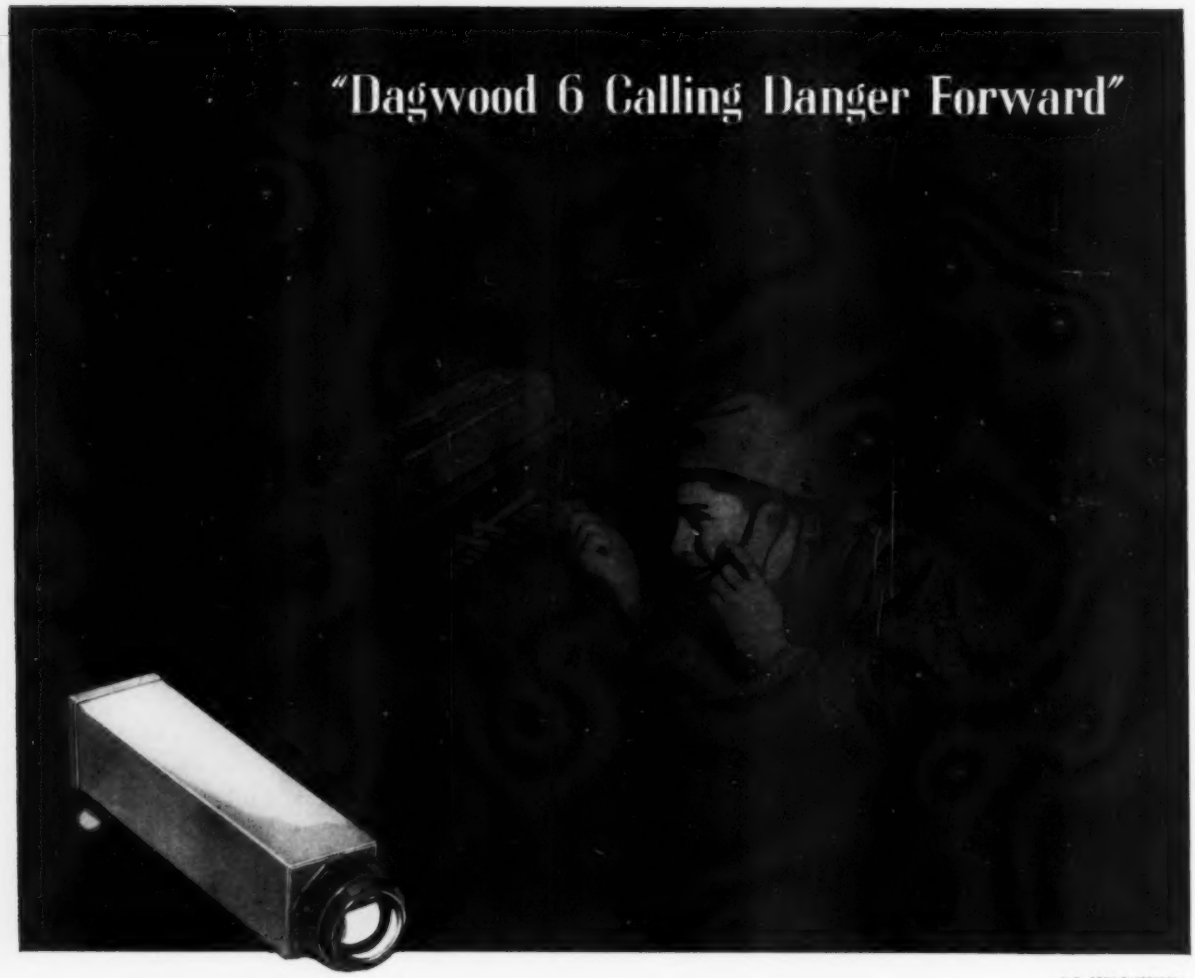
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U. S. ARMY PHOTOGRAPH

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Mr. Lloyd Bender, Vice President of The North Electric Manufacturing Company, makers of the switchboard, says of Superior, "Your performance has been excellent—in workmanship, quality of material and delivery."

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Round and Shaped Tubing available in Carbon, Alloy, and Stainless Steels, Nickel Alloys, Beryllium Copper, and Titanium



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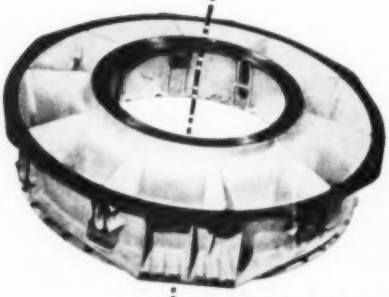
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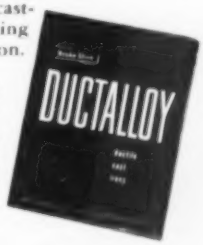
Ductalloy® castings make "impossible" parts producible



Wright J-65 jet engine main bearing support . . . impractical to machine from one piece. Readily produced as a weldment of two Ductalloy precision castings.

This highly stressed part secures the 7,200-lb. thrust Wright J-65 jet engine in the aircraft, carries major structural members ahead of and behind it, and mounts a main shaft bearing in its center. Air roars between the carefully contoured inner and outer rings.

As originally hogged out from an aluminum forging on an experimental basis, this part required some 1200 hours of machining—impractical for volume production. Redesigned by Curtiss-Wright Corporation's Wright Aeronautical Division as a weldment of two Ductalloy precision castings, it requires only simple turning and facing plus 25 ft. of welding to assemble the ten interconnecting stainless steel struts. An "impossible" part for volume manufacture in other metals which would meet specifications, it is rendered readily producible in Ductalloy—Brake Shoe's ductile cast iron that combines high strength with the casting and machining qualities of gray iron.



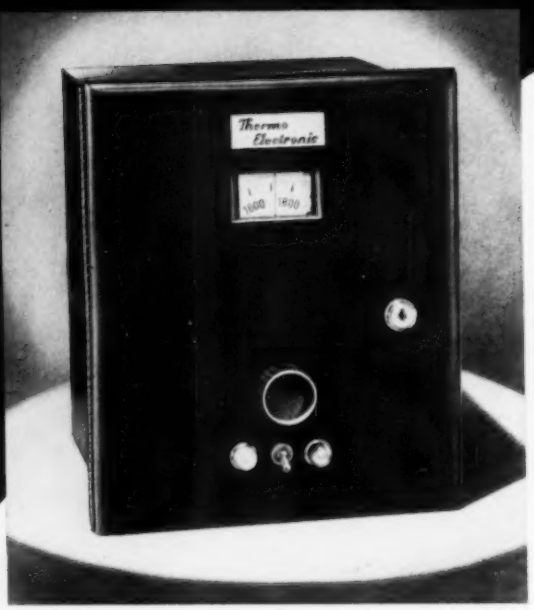
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Thermocouple Pyrometer Controller Bulletin 50H
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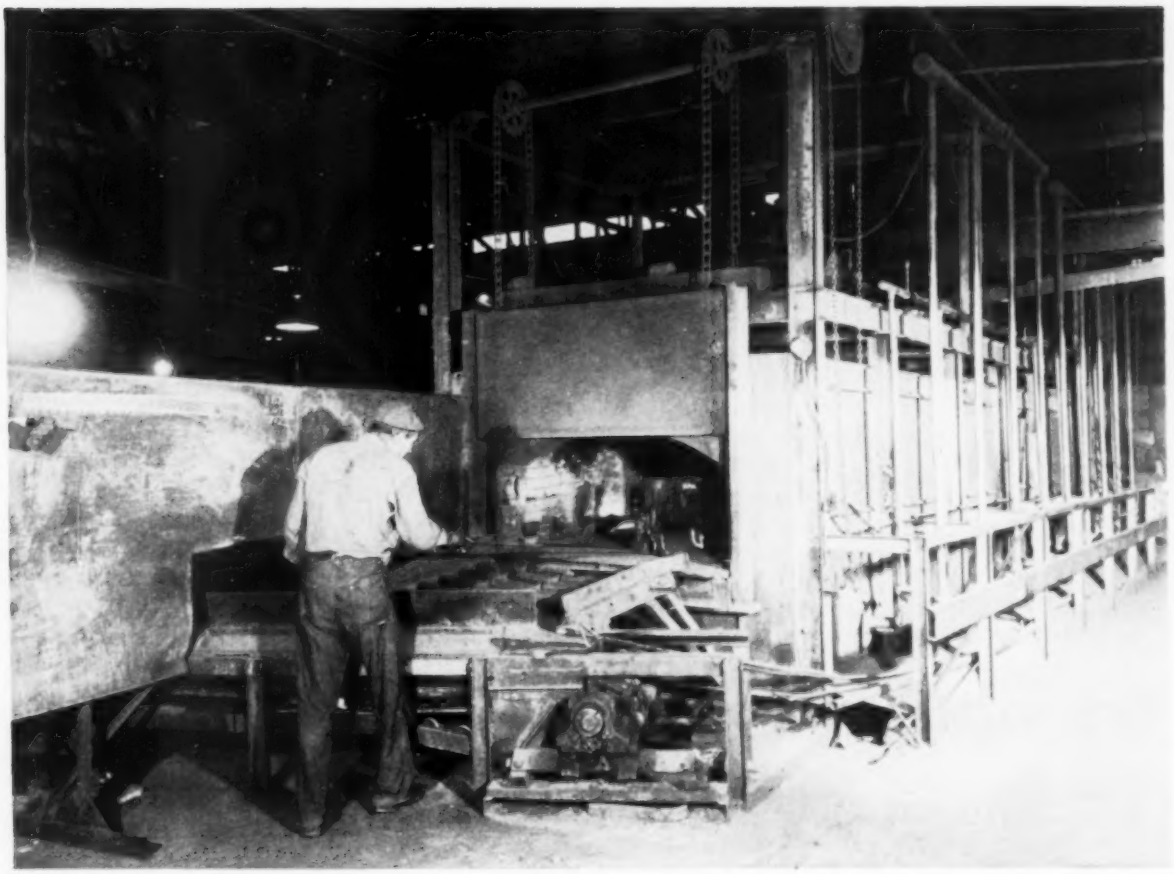
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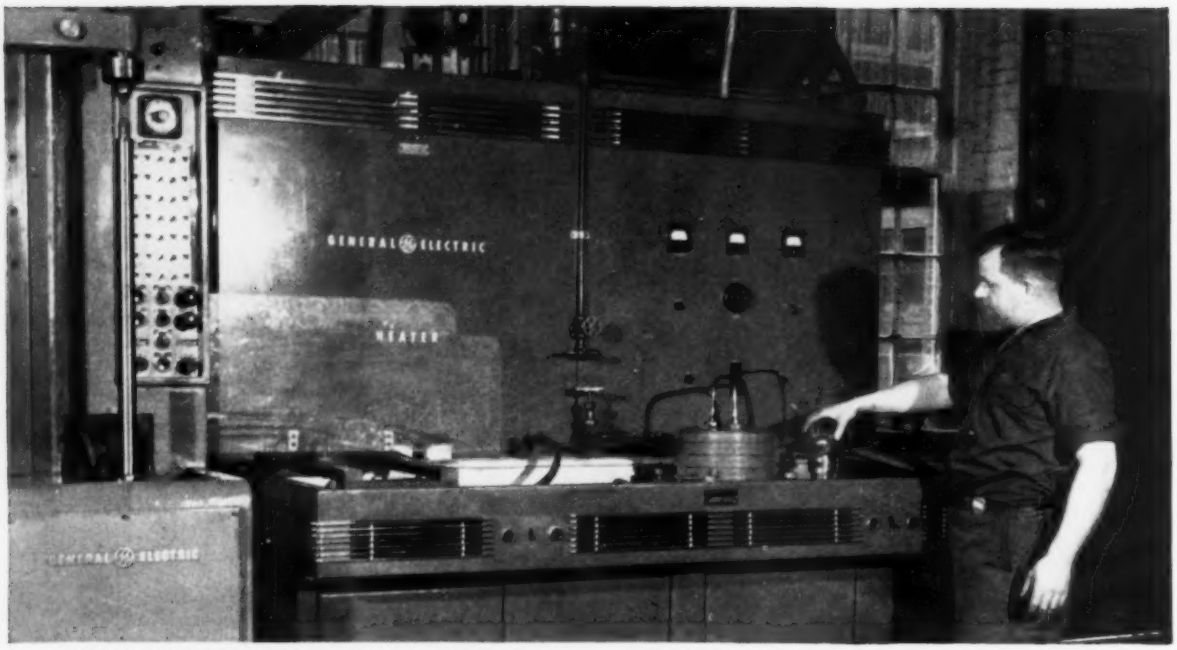
So they replaced the hearth and side tile with 2½"-thick CARBOFRAX® silicon carbide tile, and scrapped the skids and the alloy plate. The motor blocks were then pushed directly over the new floor. That was over two years ago . . . and to date *not one single* CARBOFRAX *tile has shown enough wear from abrasion to be replaced.* The only tile that have had to be replaced are a few that were accidentally cracked when blocks were tipped over on them.

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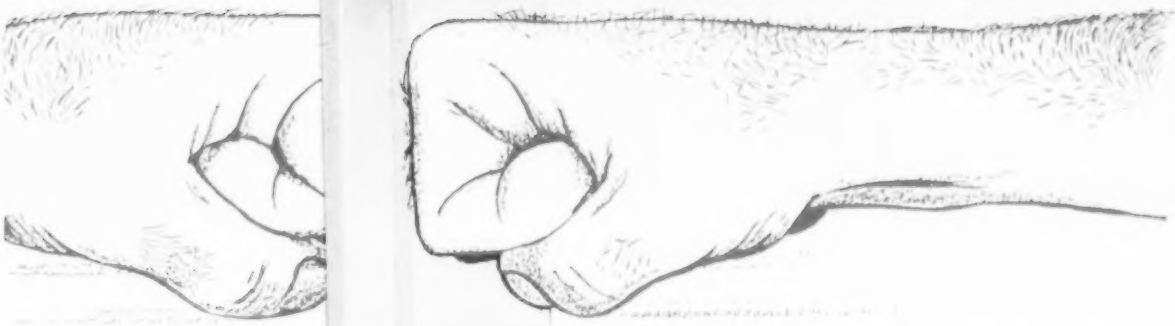
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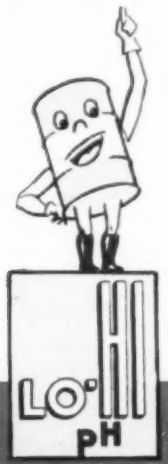


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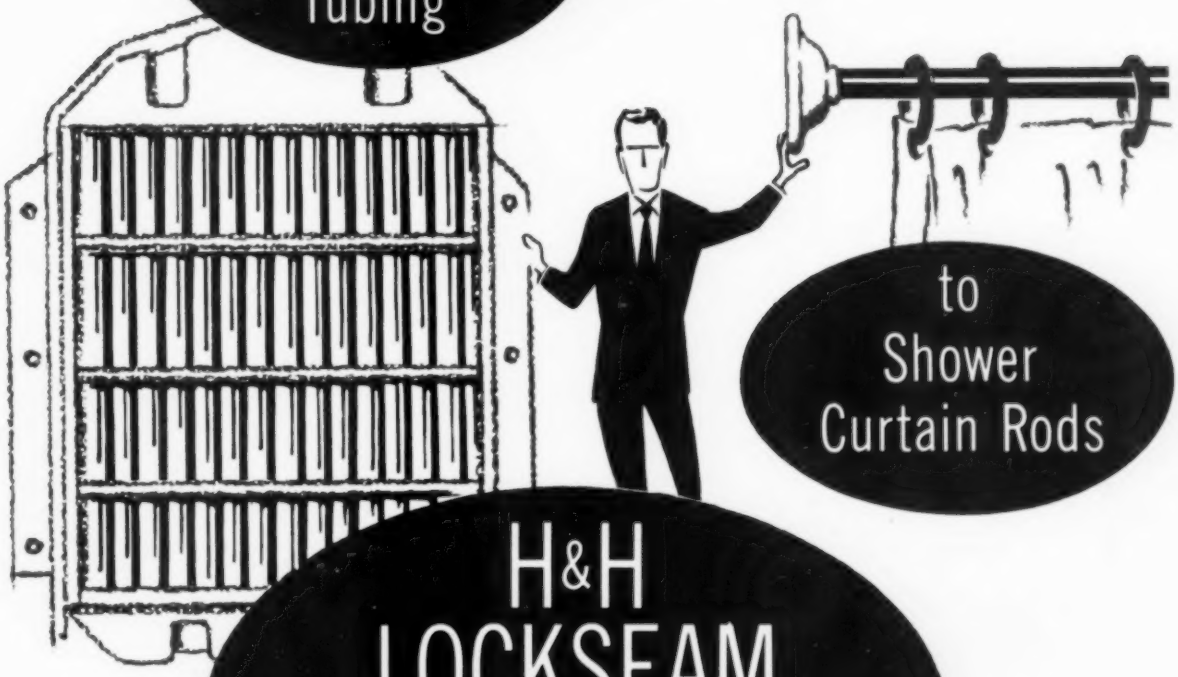
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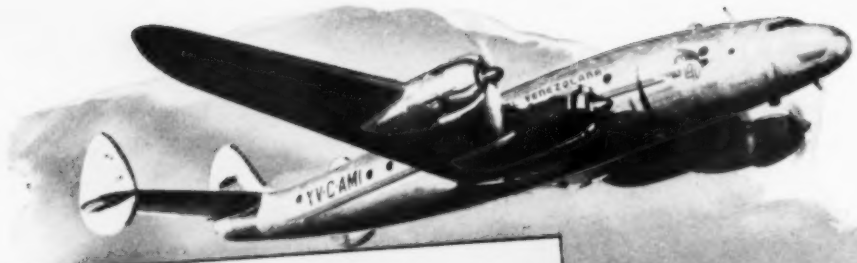
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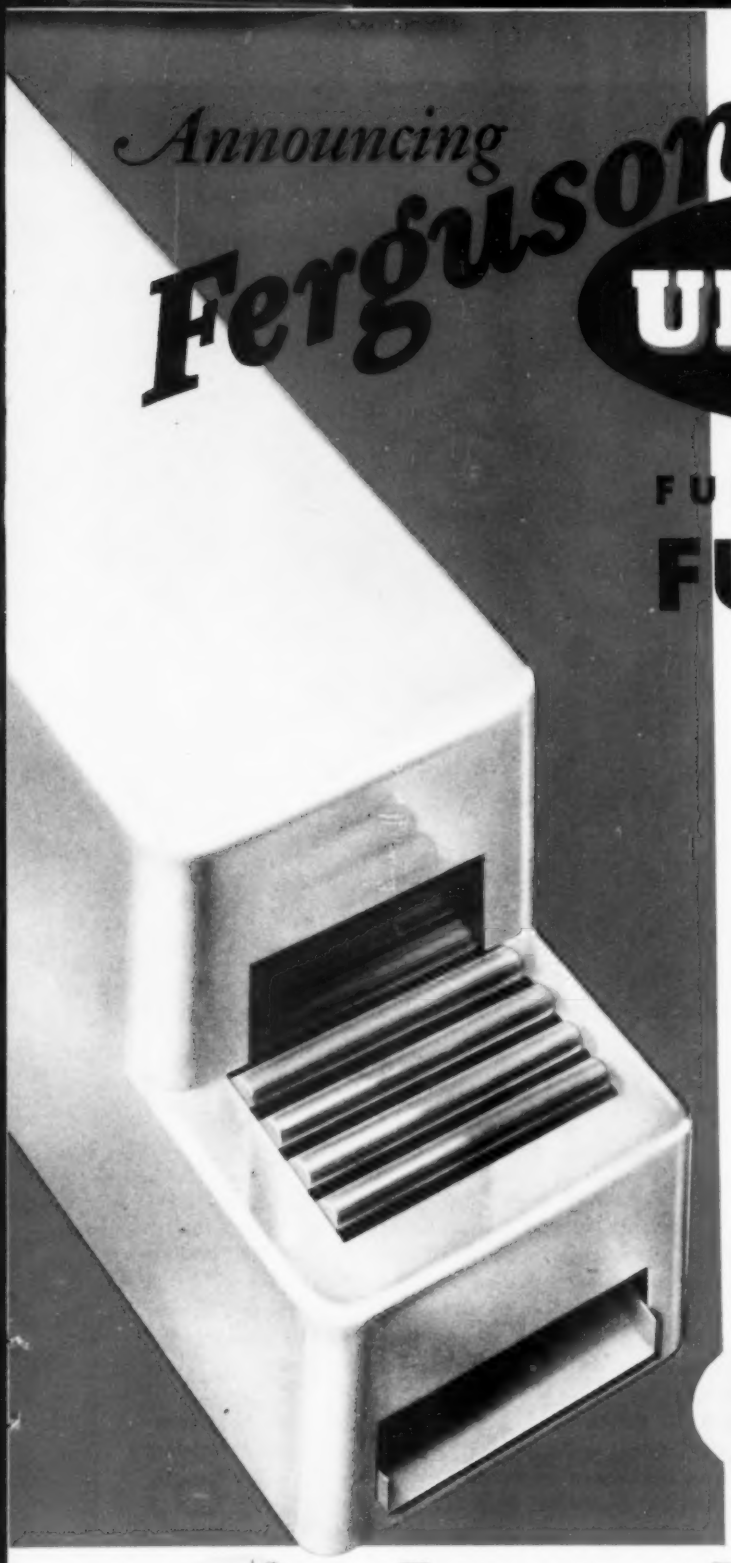




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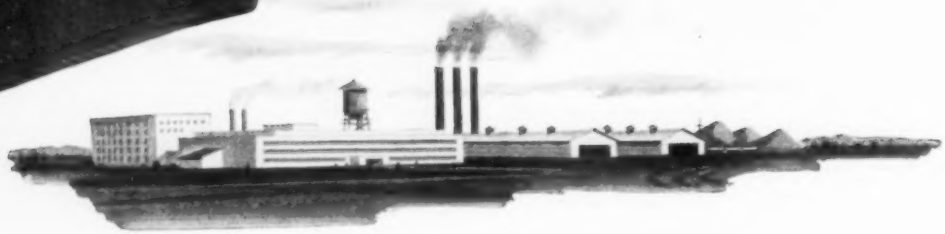
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Metal Progress

October 1953 Vol. 64 No. 4

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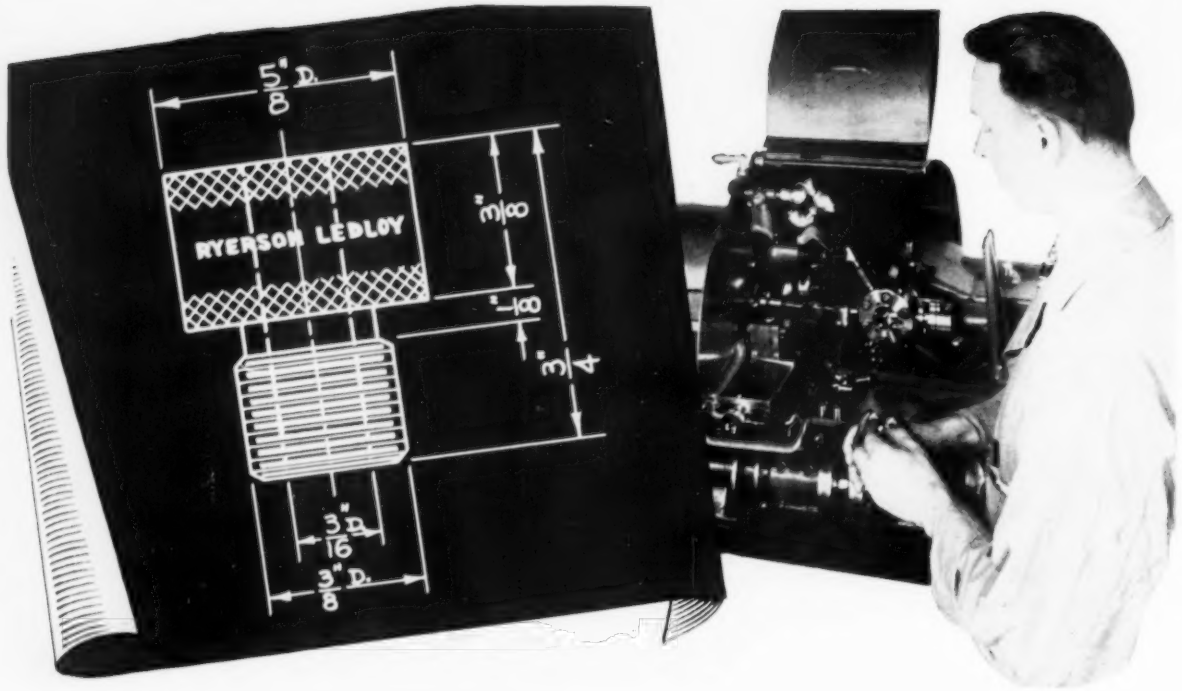
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Digest of paper by W. P. Mason and T. F. Osmer, Bell Telephone Laboratories, Inc.

Shell Molding of Magnesium 270
Digest of Report PB 111049, U. S. Department of Commerce

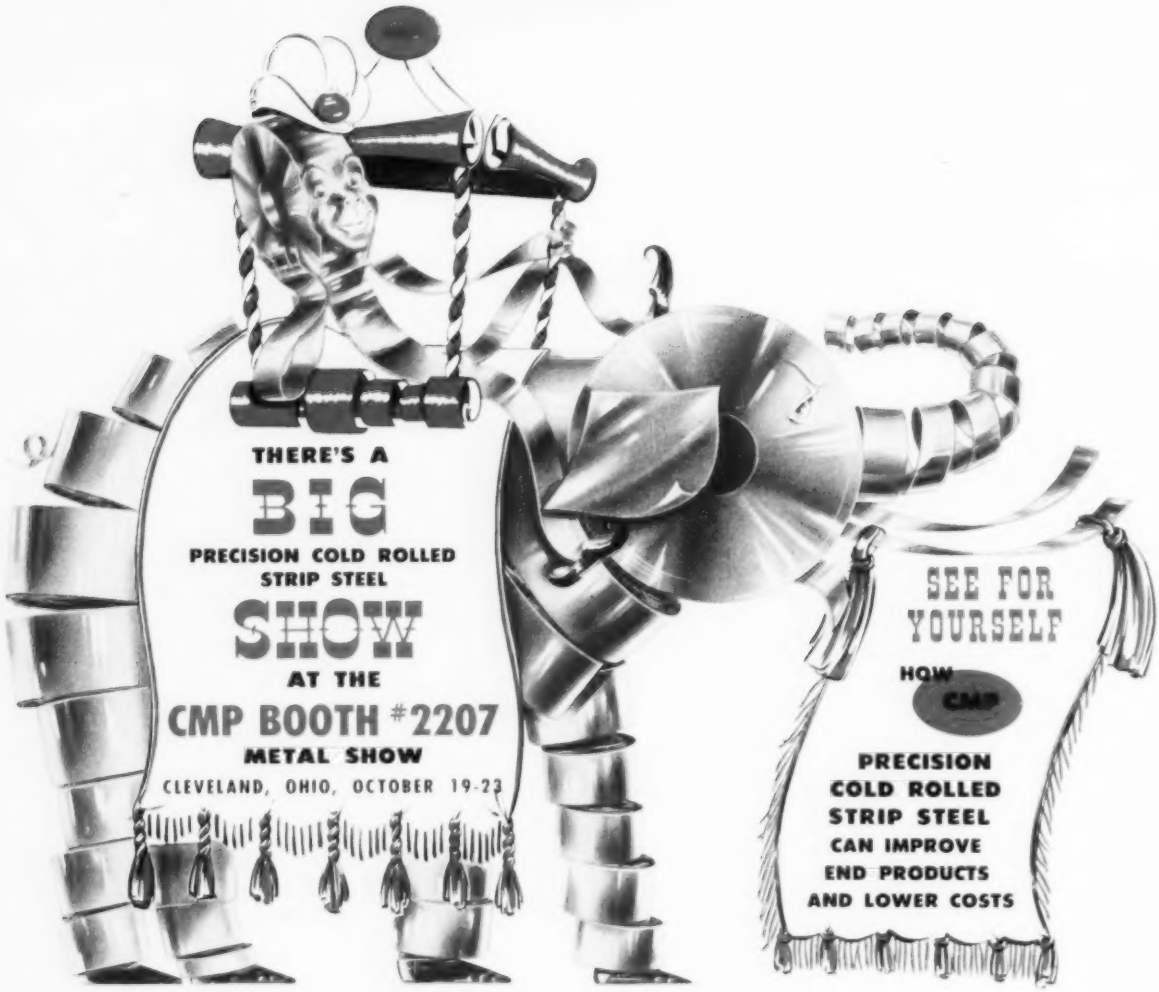
Extra! Germans Discover Induction Hardened Pinions 280
Digest of paper by Heinz Glaubitz, *Stahl und Eisen*, Sept. 27, 1951

A Test for Age Hardenability 284
Digest of paper by Roland Mitsche, *Berg- und Huttenmannische Monatshefte*

Effect of Rolling Direction, Straining and Aging on Properties of Mild Steel Plate 288
Digest of paper by C. A. Tipper, *Journal* of the Iron and Steel Institute

Summary of Knowledge of Preheating and Postheating Effects on Weld Quality 295
Digest of paper by R. D. Stout, *Welding Research Supplement*, January 1953

Casting Brass Ingots and Billets 300
Digest of paper by Maurice Cook and C. L. M. Cowley, *Journal* of the Institute of Metals, Vol. 81, March 1953



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CONSOLIDATED PROGRAM

35th National Metal Congress

AMERICAN SOCIETY FOR METALS

•

INSTITUTE OF METALS DIVISION,
AMERICAN INSTITUTE OF MINING &
METALLURGICAL ENGINEERS (A.I.M.E.)

AMERICAN WELDING SOCIETY (A.W.S.)

•

SOCIETY FOR NONDESTRUCTIVE
TESTING (S.N.T.)

•

METALS DIVISION AND METALS SECTION, SPECIAL LIBRARIES ASSOCIATION (S.L.A.)

Saturday, Oct. 17, 1953

9:30 A.M., 2:00 P.M. and 8:00 P.M.—Seminar: Relation of Properties to Microstructure, Ballroom, Statler Hotel

Sunday, Oct. 18, 1953

9:30 A.M. and 2.00 P.M.—Seminar: Relation of Properties to Microstructure; Ballroom, Statler Hotel

Monday, Oct. 19, 1953

9:00 A.M.—S.N.T. Welcoming Addresses, Ballroom, Hollenden Hotel
9:00 A.M.—S.N.T. Educational Lectures, Suite 316, Hollenden Hotel
9:30 A.M.—Titanium and Molybdenum, Ballroom, Statler Hotel
9:30 A.M.—A.I.M.E. Plastic Deformation, Ballroom, Allerton Hotel
9:30 A.M.—A.I.M.E. Metallography, Mather Room, Allerton Hotel
10:00 A.M.—A.W.S. Adams Lecture, Ballroom, Cleveland Hotel
12:00 M.—National Metal Exposition opens, Public Auditorium
2:00 P.M.—Titanium, Ballroom, Public Auditorium
2:00 P.M.—A.I.M.E. Plastic Deformation, Ballroom, Allerton Hotel
2:00 P.M.—A.I.M.E. Thermodynamics, Mather Room, Allerton Hotel
2:00 P.M.—A.I.M.E. Constitution Diagrams, Chester Room, Allerton Hotel
2:00 P.M.—A.W.S. Gouging and Cutting, Ballroom, Cleveland Hotel
2:00 P.M.—A.W.S. Resistance Welding, Red Room, Cleveland Hotel
2:00 P.M.—S.N.T. Radiography, Ballroom, Hollenden Hotel
2:15 P.M.—S.N.T. Educational Lecture, Suite 316, Hollenden Hotel
4:30 P.M.—First Lectures on Surface Protection Against Wear, Ballroom, Public Auditorium
4:30 P.M.—A.W.S. Educational Lecture, Empire Room, Cleveland Hotel
6:00 P.M.—A.W.S. President's Reception, Ballroom, Cleveland Hotel
7:45 P.M.—A.I.M.E. Recrystallization, Ballroom, Allerton Hotel
8:00 P.M.—Second Lectures on Surface Protection Against Wear, Ballroom, Public Auditorium

Tuesday, Oct. 20, 1953

9:00 A.M.—A.I.M.E. Transformation, Chester Room, Allerton Hotel
9:00 A.M.—A.I.M.E. Symposium—Titanium and Its Alloys, Ballroom, Allerton Hotel
9:00 A.M.—S.N.T. Betatron Radiography, Ballroom, Hollenden Hotel
9:30 A.M.—Mechanical, Ballroom, Hotel Statler
9:30 A.M.—Nonferrous, Ohio Room, Statler
9:30 A.M.—A.W.S. Stainless Steel, Ballroom, Cleveland Hotel
9:30 A.M.—A.W.S. Titanium, Empire Room, Cleveland Hotel
9:30 A.M.—A.W.S. Structural, Red Room, Cleveland Hotel
11:30 A.M.—Canadian Fellowship Hour and Luncheon, Statler Hotel
12:00 M.—Battelle Alumni Luncheon, Statler Hotel
2:00 P.M.—Physical Metallurgy, Ballroom, Public Auditorium
2:00 P.M.—A.I.M.E. Titanium Symposium, Ballroom, Allerton Hotel
2:00 P.M.—A.I.M.E. Creep, Chester Room, Allerton Hotel
2:00 P.M.—A.I.M.E. Research in Progress, Mather Room, Allerton Hotel

(Continued overleaf)

2:00 P.M.—A.W.S. Aluminum and Aircraft, Ballroom, Cleveland Hotel
2:00 P.M.—A.W.S. Weldability, Red Room, Cleveland Hotel
2:00 P.M.—S.N.T. Awards and Lester Honor Lecture, Ballroom, Hollenden Hotel
4:30 P.M.—🌐 First Lectures on Surface Protection Against Corrosion, Ballroom, Public Auditorium
4:30 P.M.—A.W.S. Educational Lecture, Empire Room, Cleveland Hotel
7:00 P.M.—A.I.M.E. Annual Dinner, Ballroom, Allerton Hotel
8:00 P.M.—🌐 Second Lectures on Surface Protection Against Corrosion, Ballroom, Public Auditorium

Wednesday, Oct. 21, 1953

7:30 A.M.—S.N.T. Breakfast Meeting for Members, Hollenden Hotel
7:45 A.M.—🌐 Chapter Chairmen's Breakfast, Statler Hotel
8:30 A.M.—Industrial Gas Breakfast, Hollenden Hotel
9:00 A.M.—🌐 Annual Meeting, Ballroom, Statler Hotel
9:00 A.M.—S.N.T. Isotopes and Problems of Nondestructive Testing Here and Abroad, Ballroom, Hollenden Hotel
9:30 A.M.—A.W.S. Weldability, Ballroom, Cleveland Hotel
9:30 A.M.—A.W.S. Titanium, Empire Room, Cleveland Hotel
9:30 A.M.—A.W.S. Controls and Inspection, Red Room, Cleveland Hotel
10:30 A.M.—🌐 Campbell Memorial Lecture, Ballroom, Statler Hotel
12:00 M.—Alumni Luncheons, Statler, Allerton and Hollenden Hotels
2:00 P.M.—🌐 Boron, Ballroom, Public Auditorium
2:00 P.M.—A.I.M.E. Plastic Deformation of Titanium, Molybdenum and Zirconium, Ballroom, Allerton Hotel
2:00 P.M.—A.I.M.E. Physical Metallurgy, Chester Room, Allerton Hotel
2:00 P.M.—A.I.M.E. Research in Progress, Ballroom, Allerton Hotel
2:00 P.M.—A.W.S. Pipe, Ballroom, Cleveland
2:00 P.M.—A.W.S. Research, Red Room, Cleveland Hotel
2:00 P.M.—A.W.S. Education, Empire Room, Cleveland Hotel
2:00 P.M.—S.N.T. Ultrasonics, Ballroom, Hollenden Hotel
4:30 P.M.—🌐 First Lectures on Fatigue, Ballroom, Public Auditorium
4:30 P.M.—A.W.S. Educational Lecture, Empire Room, Cleveland Hotel
6:30 P.M.—A.W.S. Section Officers Dinner, Cleveland Hotel
6:30 P.M.—A.W.S. WRC University Dinner and Conference, Cleveland Hotel
8:00 P.M.—🌐 Second Lectures on Fatigue, Ballroom, Public Auditorium

Thursday, Oct. 22, 1953

9:00 A.M.—S.N.T. Magnetic Particle and Penetrant Inspection, Ballroom, Hollenden Hotel
9:30 A.M.—🌐 Tempering, Ballroom, Public Auditorium
9:30 A.M.—🌐 Constitution, Club Room B, Public Auditorium
9:30 A.M.—A.W.S. Pressure Vessels and Research, Ballroom, Cleveland Hotel
9:30 A.M.—A.W.S. Inert-Arc Welding, Red Room, Cleveland Hotel
9:30 A.M.—A.W.S. Automatic Arc, Empire Room, Cleveland Hotel
9:30 A.M.—S.L.A. Metal Fabrication, Club Room A, Public Auditorium
10:00 A.M.—A.W.S. Board of Directors Meeting, Cleveland Hotel
1:30 P.M.—S.N.T. Eddy Current and Related Subjects, Ballroom, Hollenden Hotel
2:00 P.M.—🌐 Stainless and High Speed Steel, Ballroom, Public Auditorium
2:00 P.M.—A.W.S. Business Meeting, Ballroom, Cleveland Hotel
2:00 P.M.—S.L.A. Fundamentals of the Newer Metals, Club Room A, Public Auditorium
6:00 P.M.—S.L.A. Dinner, Mather Room, Allerton Hotel
7:00 P.M.—🌐 Annual Dinner, Ballroom, Statler Hotel
7:00 P.M.—A.W.S. Annual Dinner, Ballroom, Cleveland Hotel

Friday, Oct. 23, 1953

9:30 A.M.—🌐 Mechanical, Ballroom, Public Auditorium
9:30 A.M.—A.W.S. Applications, Ballroom, Cleveland Hotel
9:30 A.M.—A.W.S. Inert-Arc Welding, Red Room, Cleveland Hotel
9:30 A.M.—A.W.S. Field-Erected Structures, Empire Room, Cleveland Hotel
10:00 A.M.—S.L.A. Technical Session, Case Institute of Technology
12:30 P.M.—S.L.A. Luncheon, Crosby's Restaurant
2:00 P.M.—S.L.A. Visit to Warner & Swasey

Technical Program

Seminar: Relation of Properties to Microstructure

All Meetings in Ballroom, Statler Hotel, Cleveland

Saturday, Oct. 17

9:30 A.M.—First Session

Structure and Structure Sensitive Properties
by *J. H. Hollomon*, General Electric Research Laboratory

The Effect of Grain Boundaries on Mechanical Properties
by *M. Gensamer*, Columbia University

Principles of Solution Hardening
by *E. R. Parker* and *T. Hazlett*, University of California

2:00 P.M.—Second Session

Effect of Dispersion on Mechanical Properties
by *J. E. Dorn* and *C. D. Starr*, University of California

Theory of Dispersion Hardening
by *E. W. Hart*, General Electric Research Laboratory

Structure and Alloy Design
by *A. D. Schwope*, Battelle Memorial Institute

8:00 P.M.—Third Session

The Interaction of Dislocations with Solute Atoms
by *A. H. Cottrell*, The University, Birmingham, England

Sunday Oct. 18

9:30 A.M.—Fourth Session

The Relation of Fracture to Microstructure
by *J. R. Low*, General Electric Research Laboratory

The Strength of Glass Reinforced Structures
by *G. Slayter*, Owens-Corning Fiberglas Corp.

The Relation of Corrosion to Microstructure
by *H. H. Uhlig*, Massachusetts Institute of Technology

2:00 P.M.—Fifth Session

Theory of the Relation of Magnetic Properties to Microstructure
by *L. J. Dijkstra*, Westinghouse Electric Corp.

Structure and Coercivity
by *J. Libsch* and *G. Conrad*, Lehigh University

Three Educational Lecture Courses

All Sessions in Ballroom, Cleveland Public Auditorium

Surface Protection Against Wear

Monday, Oct. 19

4:30 P.M.—First Session

Techniques Selection
by *Howard S. Avery*, American Brake Shoe Co.

Electroplates and Anodizing
by *J. M. Hosdousich*, United Chromium, Inc.

Case Hardening, Diffusion Coatings, and Selective Heat Treatment
by *Michael R. Bever*, Massachusetts Institute of Technology

Metal Spraying
by *Howard Vanderpool*, Metallizing Engineering Co., Inc.

8:00 P.M.—Final Session

Hard Facing and Abrasion Resistant Alloys
by *Howard S. Avery*, American Brake Shoe Co.

Practical Examples of Surface Protection
by *Theodore Gaynor*, Bethlehem Steel Co.

Summary and Discussion
by *Howard S. Avery*, American Brake Shoe Co.

Surface Protection Against Corrosion

Tuesday, Oct. 20

4:30 P.M.—First Session

Economic Factors of Atmospheric Corrosion Versus Protection
by *Clarence C. Harvey*, Ethyl Corp.

Surface Preparation and Pre-Treatment
by *A. J. Liebman*, Bravo Corp.

Organic Coatings for Normal Service
by *Arnold J. Eickhoff*, National Lead Co.

Organic Coatings for Severe Service
by *Kenneth Tator*, Kenneth Tator Associates

8:00 P.M.—Final Session

Specifications for the Painting of Metals
by *Joseph Bigos*, Steel Structures Painting Council

Cathodic Protection and Galvanizing
by *H. A. Robinson*, Dow Chemical Co.

Metallizing
by *H. S. Ingham*, Metallizing Engineering Co., Inc.

Electrodeposited Coatings
by *Fielding Ogburn*, National Bureau of Standards

Lecture Course on Fatigue

Wednesday, Oct. 21

4:30 P.M.—First Session

Basic Concepts of Fatigue Damage in Metals
by *T. J. Dolan*, University of Illinois

Fatigue Failure Under Resonant Vibration Conditions
by *B. J. Lazan*, University of Minnesota

8:00 P.M.—Final Lecture

Fatigue Characteristics of Large Sections
by *O. J. Horger*, Timken Roller Bearing Co.

Daily Technical Sessions

Statler Hotel and Public Auditorium

Monday, Oct. 19

9:30 A.M.—Titanium and Molybdenum
BALLROOM, STATLER

Determination of Oxygen in Titanium and Zirconium by the Isotopic Method
by *A. D. Kirshenbaum*, *R. A. Mossman* and *A. V. Grosse*, Research Institute of Temple University

Vacuum-Fusion Analysis of Molybdenum
by *M. W. Mallett* and *C. B. Griffith*, Battelle Memorial Institute

Nitriding of Titanium With Ammonia
by *J. L. Watt*, Horizons, Inc. and *N. J. Grant*, Massachusetts Institute of Technology

Heat Treatment of High-Strength, Titanium-Base Alloys
by *W. M. Parris*, *P. D. Frost* and *J. H. Jackson*, Battelle Memorial Institute

2:00 P.M.—Titanium
BALLROOM, PUBLIC AUDITORIUM

Transformation Kinetics and Mechanical Properties of Titanium-Aluminum-Molybdenum Alloys
by *H. D. Kessler* and *M. Hansen*, Armour Research Foundation

Transformation Kinetics and Mechanical Properties of Titanium-Aluminum-Chromium Alloys
by *H. D. Kessler* and *M. Hansen*, Armour Research Foundation

Isothermal Transformation of Titanium-Manganese Alloys
by *P. D. Frost*, *W. M. Parris*, *L. L. Hirsch*, *J. R. Doig* and *C. M. Schwartz*, Battelle Memorial Institute

Correlation Between Heat Treatment, Microstructure and Mechanical Properties of Titanium-Molybdenum Alloys
by *D. J. DeLazzaro* and *W. Rostoker*, Armour Research Foundation

Tuesday, Oct. 20

9:30 A.M.—Mechanical
BALLROOM, STATLER

Transverse Mechanical Properties of Slack-Quenched and Tempered Wrought Steel
by *John Vajda* and *Paul E. Busby*, Carnegie Institute of Technology

A Time-Temperature Relationship for Recrystallization and Grain Growth
by *F. R. Larson* and *J. Salmas*, Watertown Arsenal

Effect of Non-Martensite Decomposition Products on the Properties of Quenched and Tempered Steels
by *E. F. Bailey*, Naval Research Laboratory

The Effect of Inclusions on the Fatigue Strength of S.A.E. 4340 Steels
by *J. T. Ransom*, E. I. du Pont de Nemours & Co.

9:30 A.M.—Nonferrous
OHIO ROOM, STATLER

The System Zirconium-Aluminum
by *D. J. McPherson* and *M. Hansen*, Armour Research Foundation

Observations on the Behavior of Hydrogen in Zirconium
by *C. M. Schwartz* and *M. W. Mallett*, Battelle Memorial Institute

Recrystallization Applied to Control of the Mechanical Properties of Molybdenum
by *J. H. Critchlow*, Westinghouse Electric Corp.

2:00 P.M.—Physical Metallurgy
BALLROOM, PUBLIC AUDITORIUM

Supercooling and Dendritic Freezing in Alloys
by *W. C. Winegard*, University of Toronto and *B. Chalmers*, Harvard University

Another Look at Quenchants, Cooling Rates and Hardenability
by *D. J. Carney*, United States Steel Corp.

The Effect of Pearlite Spacing on Transition Temperature of Steel at Four Carbon Levels
by *J. A. Rinebolt*, Naval Research Laboratory

Elevation of Critical Temperatures in Steel by High Heating Rates
by *W. J. Feuerstein* and *W. K. Smith*, U. S. Naval Ordnance Test Station, China Lake, Calif.

Wednesday, Oct. 21

9:00 A.M.—Annual Meeting
BALLROOM, STATLER

Edward de Mille Campbell Memorial Lecture
by *Donald S. Clark*, California Institute of Technology

2:00 P.M.—Boron
BALLROOM, PUBLIC AUDITORIUM

A Hypothesis for the Boron Hardenability Mechanism
by *J. W. Spretnak* and *Rudolph Speiser*, Ohio State University

The Effect of Boron on Notch Toughness and Temper Embrittlement
by *A. E. Powers* and *R. G. Carlson*, General Electric Co.

A Study of the Fe-Fe_2B System
by *C. C. McBride*, E. I. du Pont de Nemours & Co., *J. W. Spretnak* and *Rudolph Speiser*, Ohio State University

The Carbo-Nitriding of Boron Steels
by *G. W. Powell*, *M. B. Bever* and *C. F. Floe*, Massachusetts Institute of Technology

See Table of Contents, page 61, for abstracts of many of these technical papers

Thursday, Oct. 22

9:30 A.M.—Tempering

BALLROOM, PUBLIC AUDITORIUM

The Effect of Silicon on the Kinetics of Tempering
by *W. S. Owen*, University of Liverpool, England

Microstructural Changes on Tempering Iron-Carbon Alloys
by *B. S. Lement*, *B. L. Averbach* and *M. Cohen*, Massachusetts Institute of Technology

Effect of Chemical Composition on Susceptibility of Steels to Temper Brittleness
by *Ralph Hultgren* and *John Chuan Chang*, University of California

The Embrittlement of Alloy Steel at High Strength Levels
by *L. J. Klingler*, *W. J. Barnett*, *R. P. Frohnberg* and *A. R. Troiano*, Case Institute of Technology

9:30 A.M.—Constitution

CLUBROOM B, PUBLIC AUDITORIUM

Equilibrium Structures in Fe-Cr-Mo Alloys
by *J. G. McMullin*, *S. F. Reiter* and *D. G. Ebeling*, General Electric Co.

A Survey of Vanadium Binary Systems
by *W. Rostoker* and *A. Yamamoto*, Armour Research Foundation

Gamma Loop Studies in the Iron-Vanadium and the Iron-Vanadium-Titanium Systems
by *W. R. Lucas* and *W. P. Fishel*, Vanderbilt University

7:00 P.M.—Annual Banquet

BALLROOM, STATLER HOTEL

2:00 P.M.—Stainless and High Speed Steel

BALLROOM, PUBLIC AUDITORIUM

High-Temperature Transformations in Ferritic Stainless Steels Containing 17 to 25% Chromium
by *A. E. Nehrenberg* and *Peter Lillys*, Crucible Steel Co. of America

Intergranular Corrosion of Ferritic Stainless Steels
by *R. A. Lula*, *A. J. Lena* and *G. C. Kiefer*, Allegheny Ludlum Steel Corp.

Grain Growth in High Speed Steel
by *Eric Kula* and *Morris Cohen*, Massachusetts Institute of Technology

Discontinuous Grain Growth in High Speed Steel
by *A. H. Grobe*, *G. A. Roberts* and *D. S. Chambers*, Vanadium Alloys Steel Co.

Friday, Oct. 23

9:30 A.M.—Mechanical

BALLROOM, PUBLIC AUDITORIUM

Strain Aging Behavior of Rheotropically Embrittled Steel
by *E. J. Ripling*, Case Institute of Technology

Flow and Fracture of Single Crystals of High Purity Ferrite
by *R. P. Stein*, Rice Institute and *R. M. Brick*, University of Pennsylvania

Notched-Bar Tensile Properties of Various Materials and Their Relation to the Unnotch Flow Curve and Notch Sharpness
by *Harry Schwartzbart*, Armour Research Foundation and *W. E. Brown, Jr.*, National Advisory Committee for Aeronautics

Effect of Some Solid Solution Alloying Elements on the Creep Parameters of Nickel
by *Thomas Hazlett* and *Earl R. Parker*, University of California

Institute of Metals Division

American Institute of Mining and Metallurgical Engineers

All Meetings at Allerton Hotel, Cleveland

Monday Morning, Oct. 19

9:30 A.M.—Plastic Deformation

BALLROOM, ALLERTON

Plasticity of Columbium Single Crystals
by *R. Maddin* and *N. K. Chen*, Johns Hopkins University

Plastic Deformation of Iron Between 300° and 77.2 K
by *Donald E. Gibbons*, Royal Military College of Canada

Deformation of Ferrite Single Crystals
by *E. L. Vogel, Jr.* and *R. M. Brick*, University of Pennsylvania

Plastic Stress-Strain Relations for 14S-T6 Subjected to Combined Tension and Torsion
by *Joseph Marin* and *H. A. B. Wiseman*, Pennsylvania State College

9:30 A.M.—Metallography

MATHER ROOM, ALLERTON

Revealing the Subgrain Structure of Aluminum
by *M. S. Hunter* and *D. L. Robinson*, Aluminum Co. of America

Grain-Boundary Attack on Aluminum in Hydrochloric Acid and Sodium Hydroxide
by *E. C. W. Perryman*, Aluminium Laboratories Ltd.

Microscopical Examination of Tin Bronzes in the Alpha Range
by *E. C. W. Perryman*, Aluminium Laboratories Ltd.

Identification of the Precipitate Accompanying 885° F. Embrittlement in Chromium Steels
by *R. M. Fisher*, *E. J. Dulis* and *K. G. Carroll*, United States Steel Corp.

Measurement of Particle Sizes in Opaque Bodies
by *R. L. Fullman*, General Electric Co.

Measurement of Approximately Cylindrical Particles of Opaque Samples
by *R. L. Fullman*, General Electric Co.

Institute of Metals Division, A.I.M.E.

Monday Afternoon (Cont.)

2:00 P.M.—Plastic Deformation

BALLROOM, ALLERTON

Plastic Deformation of Single Crystals of Copper
by *J. J. Becker*, General Electric Research Lab. and *J. N. Hobstetter*, Bell Telephone Labs.

Orientation Relationships in the Recrystallization of Deformed Copper Single Crystals
by *J. J. Becker*, General Electric Research Lab. and *J. N. Hobstetter*, Bell Telephone Labs.

Plastic Deformation of Rectangular Zinc Monocrystals
by *John J. Gilman*, Columbia University

Variation of Plastic Properties With Annealing Procedure in Zinc Single Crystals
by *Choh Hsien Li*, *Jack Washburn* and *Earl R. Parker*, University of California

Recovery in Single Crystals of Zinc
by *R. Drouard*, Paris
Jack Washburn and *Earl R. Parker*, University of California

Some Observations on the Work Hardening of Metals
by *E. H. Edwards*, *Jack Washburn* and *E. R. Parker*, University of California

2:00 P.M.—Thermodynamics

MATHER ROOM, ALLERTON

Some Applications of the Thermodynamic Theory of Irreversible Processes to Physical Metallurgy
by *E. S. Machlin*, Columbia University

Vapor Pressure of Silver Over Silver-Gold Solid Solutions
by *C. L. McCabe*, *H. M. Schadel, Jr.*, Carnegie Institute of Technology and *C. E. Birchenall*, Princeton University

Vapor Pressure of Silver
by *C. L. McCabe*, Carnegie Institute of Technology and *C. E. Birchenall*, Princeton University

High-Pressure Oxidation Rate of Metals—Copper in Oxygen
by *William McKeown*, New Jersey Zinc Co. of Pa. and *W. Martin Fassell, Jr.*, University of Utah

Self-Diffusion of Iron in Iron Oxides and the Wagner Theory of Oxidation
by *L. Himmel*, *R. F. Mehl*, Carnegie Institute of Technology and *C. E. Birchenall*, Princeton University

Decay of Lattice Defects Frozen Into an Alloy by Quenching
by *A. E. Roswell* and *A. S. Nowick*, Yale University

2:00 P.M.—Constitution Diagrams

CHESTER ROOM, ALLERTON

Ternary System Ti-Ta-C
by *John G. McMullin*, General Electric Research Laboratories and *John T. Norton*, Massachusetts Institute of Technology

Titanium-Rich Corners of the Ti-C-N, Ti-C-O and Ti-N-O Phase Diagrams
by *L. Stone* and *H. Margolin*, New York University

System Titanium-Chromium-Iron
by *R. I. Van Thyne*, *H. D. Kessler* and *M. Hansen*, Armour Research Foundation

Vanadium-Uranium Constitutional Diagram
by *H. A. Saller* and *F. A. Rough*, Battelle Memorial Institute

Order-Disorder Transformation in Cu-Au Alloys Near the Composition CuAu
by *J. B. Neukirk*, General Electric Co.

Analysis of Molten Zone Refining
by *N. W. Lord*, Raytheon Mfg. Co.

7:45 P.M.—Panel Discussion on Recrystallization

BALLROOM, ALLERTON

B. L. Averbach, Moderator

Do Metals Recrystallize
Paul A. Beck, Panel Leader

Interfacial Energy and Recrystallization
Cyril Stanley Smith, Panel Leader

Recovery
B. L. Averbach, Panel Leader

Stored Energy and Recrystallization
E. E. Stansbury, Panel Leader

Significance of Activation Energies
D. Turnbull, Panel Leader

Recrystallization as a Nucleation and Growth Process
J. E. Burke, Panel Leader

Textures and Recrystallization
Robert Maddin, Panel Leader

Tuesday, Oct. 20

9:00 A.M.—Transformation

CHESTER ROOM, ALLERTON

Silver-Cadmium Eutectoid
by *G. R. Speich*, Westinghouse Electric Corp. and *D. J. Mack*, University of Wisconsin

Diffusionless Phase Change in the Indium-Thallium System
by *M. W. Burkart* and *T. A. Read*, Columbia University

On the Theory of the Formation of Martensite
by *M. S. Wechsler*, *D. S. Lieberman* and *T. A. Read*, Columbia University

Rate of Propagation of Martensite
by *R. F. Bunshah*, *R. F. Mehl*, Carnegie Institute of Technology

Rate of Formation of Isothermal Martensite in Fe-Ni-Mn Alloy
by *R. E. Cech* and *J. H. Hollomon*, General Electric Co.

Calculation of Martensite Nucleus Energy Using the Reaction-Path Model
by *J. C. Fisher* and *D. Turnbull*, General Electric Co.

Martensite Nucleation in Substitutional Iron Alloys
by *John C. Fisher*, General Electric Co.

Stabilization of the Austenite-Martensite Reaction in a High-Chromium Steel
by *S. C. Das Gupta*, *B. S. Lement*, Massachusetts Institute of Technology

Institute of Metals Division, A.I.M.E.

Tuesday's Program (Cont.)

9:00 A.M.—Symposium on Physical Metallurgy of Titanium and Its Alloys

BALLROOM, ALLERTON

Effect of Hydrogen on Mechanical Properties of Titanium
by *G. A. Lenning*, *C. M. Craighead* and *R. I. Jaffee*, Battelle Memorial Institute

Initial Experience With a New Type Titanium Alloy — the All-Alpha
by *W. L. Finlay*, *R. W. Parcel* and *R. C. Durstein*, Rem-Cru Titanium Inc.

Isothermal Characteristics of Ti-Fe-V Alloys
by *W. P. Koster*, *J. F. Kahles*, Metcut Research Associates and *L. S. Busch*, Mallory-Sharon Titanium Corp.

Research and Development Program at Wright Air Development Center
by *E. J. Hassell*, Wright Air Development Center

12:15 P.M.—I.M.D. Executive Committee Luncheon Meeting

OTIS ROOM, ALLERTON

2:00 P.M.—Symposium on Physical Metallurgy of Titanium and Its Alloys

BALLROOM, ALLERTON

Hardening and Embrittlement of Beta-Stabilized Titanium Alloys
by *W. M. Parris*, *A. P. Young*, *A. J. Griest, Jr.* and *P. D. Frost*, Battelle Memorial Institute

Titanium-Base Alloys for Elevated-Temperature Applications
by *H. D. Kessler* and *F. A. Crossley*, Armour Research Foundation

The Influence of Metallurgical Factors on the Mechanical Properties of Titanium Alloys
by *Schuyler Heries*, Titanium Metals Corp. of America

Heat Treatment, Structure and Mechanical Properties of Titanium-Manganese Alloys
by *F. C. Holden*, *H. R. Ogden* and *R. I. Jaffee*, Battelle Memorial Institute

Heat Treatment and Alloying of Titanium
by *L. D. Jaffe*, Watertown Arsenal Laboratory

2:00 P.M.—Creep

CHESTER ROOM, ALLERTON

Inhomogeniety in Creep Deformation of Coarse-Grained High-Purity Aluminum
by *H. C. Chang* and *N. J. Grant*, Massachusetts Institute of Technology

Kink Band Formation in High-Purity Aluminum During Creep at High Temperatures
by *A. M. Gervais* (Société Commentry-Fouchambault et Decazeville), *J. T. Norton* and *N. J. Grant* (Massachusetts Institute of Technology)

Subgrain Formation in High-Purity Aluminum During Creep at High Temperatures
by *Andre M. Gervais* (Société Commentry-Fouchambault et Decazeville), *John T. Norton* and *Nicholas J. Grant* (Massachusetts Institute of Technology)

Metallographic Observations of the Deformation of High-Purity Magnesium in Creep at 500° F.
by *A. R. Chaudhuri*, *N. J. Grant* and *J. T. Norton*, Massachusetts Institute of Technology

Creep Behavior of Extruded Electrolytic Magnesium
by *C. S. Roberts*, Dow Chemical Co.

Further Progress in the Development of Mg-Zr Alloys to Give Good Creep and Fatigue Properties Between 500 and 650° F.
by *C. J. P. Ball*, *A. C. Jessup*, *P. A. Fisher*, *D. J. Whitehead* and *J. B. Wilson*, Magnesium Elektron Ltd.

Properties of Sand Cast Magnesium-Thorium-Zinc-Zirconium Alloys
by *K. E. Nelson*, Dow Chemical Co.

A Rationalization of Measured High-Temperature Properties of Fe-Cr-Co-Ni Alloys
by *J. D. Nisbet* and *W. R. Hibbard, Jr.*, General Electric Co.

2:00 P.M.—Research in Progress*

MATHER ROOM, ALLERTON

Heat Treatment of Titanium Alloys Generalized in Terms of B
by *Leonard D. Jaffe*, Watertown Arsenal

Solid-State Bonding of Aluminum and Nickel
by *S. Storchheim*, *J. L. Zambrow* and *H. H. Hausner*, Sylvania Electric Products, Inc.

Grain-Boundary Creep
by *F. N. Rhines*, Carnegie Institute of Technology

The Spread in Orientations Among Microregions in Cast and Deformed Crystals
by *W. C. Ellis*, Bell Telephone Laboratories, Inc.

Growth Structure Formed During the Solidification of Metal Crystals
by *C. Elbaum*, University of Toronto and *B. Chalmers*, Harvard University

Curie Temperatures of Certain Ternary Sigma Alloys
by *M. V. Nevitt* and *P. A. Beck*, University of Illinois

The Effect of Grain Size on Ultrasonic Transmissibility
by *Nicholas Grossman*, Sylvania Electric Products, Inc.

Mechanism of Plastic Flow in Titanium at Low and High Temperatures
by *F. D. Rosi* and *F. C. Perkins*, Sylvania Electric Products, Inc.

Arsenic-Bismuth Phase Diagram
by *G. A. Geach* and *R. A. Jeffrey*, Associated Electrical Industries, Ltd., Berkshire, England

Deformation Bands in Titanium
by *G. A. Geach* and *A. T. Churchman*, Associated Electrical Industries, Ltd.

*The Research in Progress reports listed on the Tuesday afternoon session will be divided, some of them being presented on Wednesday afternoon.

Institute of Metals Division, A.I.M.E.

Tuesday Afternoon (Cont.)

Some Factors Governing the Microhardness of Pure Metals
by *G. A. Geach* and *J. Winton*, Associated Electrical Industries, Ltd.

Crystallization of Silicon From Solution in Tin
by *A. J. Goss*, Bell Telephone Laboratories, Inc.

The Influence of Isotope Mass on the Physical Properties of Iron
by *Pol Duwez* and *James O. McCaldin*, California Institute of Technology

Solubility of Oxygen in Alpha Iron
by *A. U. Seybolt*, General Electric Co.

Temperature Dependence of Brittle Fracture in Ductile Metals
by *J. J. Gilman*, General Electric Co.

Polygonization in Zinc
by *J. J. Gilman*, General Electric Co.

The Effect of Ultrasonic Irradiation on Metallurgical Reactions and Processes
by *L. McD. Schetky*, Rensselaer Polytechnic Institute

Properties of Magnesium Alloy Single Crystals at Room and Elevated Temperatures
by *R. R. Nash* and *Arthur A. Burr*, Rensselaer Polytechnic Institute

Continuous Cooling Transformation Studies With the High Speed Dilatometer
by *E. C. Nelson* and *E. F. Nippes*, Rensselaer Polytechnic Institute

Behavior of Stressed Magnesium Single Crystals Below the Critical Resolved Shear Stress
by *David Krashes* and *Arthur A. Burr*, Rensselaer Polytechnic Institute

Origin of the Cube Texture in Copper
by *A. Merlini* and *P. A. Beck*, University of Illinois

6:00 P.M.—Cocktail Party for Dinner Guests
CHESTER ROOM, ALLERTON

7:00 P.M.—Annual I.M.D. Fall Dinner
BALLROOM, ALLERTON

Wednesday, Oct. 21

2:00 P.M.—Plastic Deformation of Titanium, Molybdenum and Zirconium
BALLROOM, ALLERTON

Deformation Mechanisms in Alpha Titanium
by *E. A. Anderson, D. C. Jillson* and *S. R. Dunbar*, New Jersey Zinc Co. of Pa.

Cold Rolled Texture of Titanium
by *D. N. Williams* and *D. S. Eppelsheimer*, University of Missouri

Effects of Solid Solution Alloying on the Cold Rolled Texture of Titanium
by *Carl J. McHargue*, University of Kentucky
Sam E. Adair, Jr., Linde Air Products Co.
and *Joseph P. Hammond*, University of Kentucky

Textures of Rolled and Annealed Iodide Zirconium
by *J. H. Keeler, W. R. Hibbard, Jr.* and *B. F. Decker*, General Electric Co.

2:00 P.M.—Physical Metallurgy
CHESTER ROOM, ALLERTON

Effects of Macrostructure on the Performance of Alnico Permanent Magnets
by *Dolph G. Ebeling*, General Electric Co.
and *Arthur A. Burr*, Rensselaer Polytechnic Institute

Densification and Kinetics of Grain Growth During the Sintering of Chromium Carbide
by *H. J. Hamjian*, Utica Drop Forge and Tool Corp.
and *W. G. Lidman*, Sylvania Electric Products, Inc.

Influence of Aluminum and Silicon Deoxidation on the Strain Aging of Low-Carbon Steels
by *W. C. Leslie* and *R. L. Rickett*, U. S. Steel Corp.

Age Softening of Beta Brass
by *Harry Green*, Horizons Inc.
and *Norman Brown*, University of Pennsylvania

Anelastic Behavior of Pure Gold Wire
by *Donald R. Mash* and *Lewis D. Hall*, Stanford University

Some Properties of Columbium Containing Nitrogen
by *Chuh-Yi Ang* and *Charles Wert*, University of Illinois

Electrical Resistivity of Liquid Metals and of Dilute Liquid Metallic Solutions
by *E. Scala*, Chase Brass & Copper Co.
and *W. D. Robertson*, Yale University

2:00 P.M.—Research in Progress*
MATHER ROOM, ALLERTON

*See footnote on p. 69.

American Welding Society

All Meetings at Cleveland Hotel

Monday, Oct. 19

10:00 A.M.—Award of Prizes and Adams Lecture
BALLROOM, CLEVELAND

Aspects of Welding Research in British Merchant Shipbuilding
by *R. B. Shepheard*, The Shipbuilding Conference

2:00 P.M.—Gouging and Cutting
BALLROOM, CLEVELAND

The Arcair Process
by *Myron D. Stepath*, Arcair Co.

Shielded Metal-Arc Cutting and Grooving
by *Helmut Thielsch* and *J. Quaas*, Eutectic Welding Alloys Corp.

Advanced Automatic Flame Cutting for Machinery Weldments
by *Howard B. Cary*, Marion Power Shovel Co.

2:00 P.M.—Resistance Welding

RED ROOM, CLEVELAND

Radiography of Spot Welds
by *Robert C. McMaster*, Battelle Memorial Institute

Resistance Welding in Jet Engine Manufacturing
by *Frank J. Wallace* (Pratt and Whitney Aircraft Div., United Aircraft Corp.)

A Study of the Cooling Rates in Flash Welds in Steel
by *Ernest F. Nippes*, *Warren F. Savage* and *Gordon Grotke* (Rensselaer Polytechnic Institute)

Some Applications of High-Speed Motion Picture Photography to Resistance Welding
by *I. S. Goodman*, Westinghouse Electric Corp.

4:30 P.M.—Educational Lecture Series

EMPIRE ROOM, CLEVELAND HOTEL

Scientific Basis of Welding
by *H. Udin*, Massachusetts Institute of Technology

6:00 P.M.—President's Reception and National Officers' Dinner

BALLROOM, CLEVELAND HOTEL

Tuesday, Oct. 20

9:30 A.M.—Stainless Steel

BALLROOM, CLEVELAND

Factors Which Influence Weld Hot Cracking
by *W. R. Apblett* and *W. S. Pellini*, Naval Research Laboratory

Silver Brazing Alloys for Corrosion Resistant Joints in Stainless Steels
by *George H. Sistare*, Handy & Harman
L. H. Grenell, General Motors Corp.
and *John T. Halbig*, Armco Steel Corp.

Submerged-Arc Welding of Chromium-Bearing Steels
by *Clarence E. Jackson* and *Arthur E. Shrubsall* (Union Carbide & Carbon Laboratories)

9:30 A.M.—Titanium

EMPIRE ROOM, CLEVELAND

Tension, Shear and Impact Strengths of Spot Welded Titanium Joints
by *M. L. Begeman*, *E. H. Block, Jr.* and *Frank W. McBee, Jr.* (University of Texas)

Fusion Welding Commercially Pure Titanium
by *Francis H. Stevenson*, Aerojet General Corp.

Alloy Filler Metals in Commercially Pure Titanium
by *Carl E. Hartbower*, Watertown Arsenal Laboratory

9:30 A.M.—Structural

RED ROOM, CLEVELAND

Further Studies of Welded Corner Connections
by *A. A. Toprac*, University of Texas
and *Lynn S. Beedle*, Lehigh University

Weldability of Structural Steel Discussed From the Viewpoint of Federal Agencies
by *E. I. Erickson*, Bridge Branch, Bureau of Public Roads

Development of Welded Bridge Construction
by *N. W. Morgan* (Principal Highway Bridge Engineer, Bureau of Public Roads)

Recent Applications of Welded Design to Industrial Building Framings
by *A. Amirikian* and *E. G. Odley* (Bureau of Yards and Docks, Navy Department)

2:00 P.M.—Aluminum and Aircraft

BALLROOM, CLEVELAND

Soldering of Aluminum
by *James D. Doud*, Aluminum Co. of America

Fatigue Strength of Welded Butt Joints in $\frac{3}{8}$-In. Thick Aluminum Alloy Plates
by *E. C. Hartmann*, *Marshall Holt* and *I. D. Eaton* (Aluminum Co. of America)

Some Considerations on Weldability of Aluminum Alloys
by *J. Koziarski*, Piasecki Helicopter Corp.

2:00 P.M.—Weldability

RED ROOM, CLEVELAND

Ductility Transition Characteristics of Weld Metal
by *Earl Eschbacher* and *W. S. Pellini*, Naval Research Laboratory

Further Studies on Weld-Metal Microcracking in Mild Steel
by *A. E. Flanigan*, University of California

4:30 P.M.—Educational Lecture Series

EMPIRE ROOM, CLEVELAND HOTEL

Scientific Basis of Welding
by *H. Udin*, Massachusetts Institute of Technology

Wednesday, Oct. 21

9:30 A.M.—Weldability

BALLROOM, CLEVELAND

Army First Pass Groove Weld Crack Susceptibility Test
by *Z. J. Fabrykowski*, *S. Goodman* and *R. A. Scherer* (Detroit Arsenal)

Low-Temperature Bend-Test Properties of Bead-on-Plate Welds
by *L. S. Harris*, *R. B. Matthiesen* and *N. M. Newmark* (University of Illinois)

Fatigue Properties of Weld Metal
by *L. S. Harris*, *R. B. Matthiesen* and *N. M. Newmark* (University of Illinois)

9:30 A.M.—Titanium

EMPIRE ROOM, CLEVELAND

A Study of the Weld Heat-Affected Zones in Titanium Alloys
by *Ernest F. Nippes*, *John M. Gerken* and *Bernard W. Schaat* (Rensselaer Polytechnic Institute)

Welding Characteristics of Titanium and Titanium Alloys
by *Mario L. Ochiuzzo*, Lockheed Aircraft Corp.

Study of the Effects of Alloying Elements on the Weldability of Titanium Sheet
by *W. Rostoker* and *H. M. Meyer* (Armour Research Foundation)

American Welding Society

Wednesday Morning (Cont.)

9:30 A.M.—Controls and Inspection
RED ROOM, CLEVELAND

Inspection Techniques for Quality Welding Production
by *Lew Gilbert*, Industry and Welding and *William B. Bunn*, M. W. Kellogg Co.

Nondestructive Testing as an Aid to the Increased Use of Welding for Steel Structures
by *Lloyd J. Oye*, Magnaflux Corp.

Tolerances on Fillet Welds
by *John Mikulak* and *Merle B. Dillman*, Worthington Corp.

2:00 P.M.—Pipe
BALLROOM, CLEVELAND

Further Studies of the Arc Welding of Low-Chromium Molybdenum Steel Pipe
by *J. Bland*, Standard Oil Co. (Ind.)

Superheaters for 1100 to 1500° F. Test Installation
by *Bela Ronay* and *W. E. Clautice*, U. S. Naval Engineering Experiment Station

Carbide Segregation in 1¼ Cr, ½ Mo Steel Pipe Welded Joints
by *I. A. Rohrig*, Detroit Edison Co. and *H. S. Blumberg*, M. W. Kellogg Co.

2:00 P.M.—Research
RED ROOM, CLEVELAND

Welding Metallurgy of Nodular Cast Iron
by *Edward E. Hucke* and *H. Udin*, Massachusetts Institute of Technology

The Effect of Low-Temperature Stress-Relieving on Stress-Corrosion Cracking of Mild Steel
by *C. R. McKinsey*, Union Carbide and Carbon Research Laboratories, Inc.

Transformation of Cr-Mo Steels During Welding
by *W. R. Apblett, Jr.*, *R. P. Dunphy* and *W. S. Pellini*, Naval Research Laboratory

Multiple Contact Resistance
by *W. B. Kouwenhoven* and *Donald R. Hagner*, Johns Hopkins University

2:00 P.M.—Education
EMPIRE ROOM, CLEVELAND

Teaching Engineering Fundamentals
by *S. C. Hollister*, Cornell University

Discussion by *W. B. Kouwenhoven*, Johns Hopkins University and *R. S. Green*, Ohio State University

Teaching Welding Design
by *J. P. Vidosic*, Georgia Institute of Technology

4:30 P.M.—Educational Lecture Series
EMPIRE ROOM, CLEVELAND HOTEL

Scientific Basis of Welding
by *H. Udin*, Massachusetts Institute of Technology

6:30 P.M.—Section Officers Dinner

6:30 P.M.—W.R.C. University Dinner and Conference

Thursday, Oct. 22

9:30 A.M.—Pressure Vessels and Research
BALLROOM, CLEVELAND

Plastic Fatigue Strength of Pressure Vessel Steels
by *Robert D. Stout*, *John H. Gross* and *D. E. Gucer*, Lehigh University

A Qualitative Study of Residual Stresses in Welds by Photo-Elasticity
by *Melvin Mark*, Raytheon Mfg. Co.

Effect of Nitrogen and Carbon Dioxide Atmospheres on Arc Welding
by *Professors Sowa*, *Truckenmiller* and *Wagner*, University of Michigan

Biaxial Fatigue Properties of Pressure-Vessel Steels
by *T. J. Dolan* and *C. E. Bowman*, University of Illinois

9:30 A.M.—Inert-Arc Welding
RED ROOM, CLEVELAND

Inert-Gas-Shielded Metal-Arc Welding of Low-Carbon Steels
by *George C. Christopher* and *R. C. Becker*, International Harvester Co.

Characteristics of Consumable-Electrode Inert Arcs
by *R. W. Tuthill*, General Electric Co.

Effect of Power Supply Characteristics on Sigma Welding
by *W. H. Helmbrecht* and *R. L. Hackman*, Linde Air Products Co.

Weld Properties of a Carbon Steel Electrode for Use With Inert-Gas Shields
by *Harry C. Cook* and *Gilbert R. Rothschild*, Air Reduction Research Laboratories

9:30 A.M.—Automatic Arc
EMPIRE ROOM, CLEVELAND

New Developments in Fluxes for Automatic Welding and Hard Surfacing
by *L. K. Stringham*, Lincoln Electric Co.

Multiple-Electrode Welding by the Unionmelt Process
by *D. E. Knight*, Linde Air Products Co.

Twinarc Submerged-Arc Welding
by *Theodore Ashton*, Lincoln Electric Co.

2:00 P.M.—Annual Business Meeting

7:00 P.M.—Annual Dinner

Friday, Oct. 23

9:30 A.M.—Applications
BALLROOM, CLEVELAND

New Welding Shop Facilities, Methods and Equipment at the Whiting Refinery
by *Ray M. Kolb* and *R. C. Wheeler*, Standard Oil Co. (Ind.)

Silver and Gold for Brazing Electronic Components
by *A. W. Swift* and *R. J. Metzler*, Handy & Harman

New Results in Tool and Die Welding
by *Robert H. Groman*, Eutectic Welding Alloys Corp.

Austenitic Manganese Steel Welding Electrodes
by *Howard S. Avery* and *Henry J. Chapin*, American Brake Shoe Co.

9:30 A.M.—Inert-Arc Welding
RED ROOM, CLEVELAND

A New Method to Prevent Rectification of Current and High-Frequency Interference in Inert-Gas Arc Welding
by *John Murray*, Lincoln Electric Co.

New Developments in Sigma Welding of Carbon Steel
by *T. McElrath, Jr.* and *R. T. Telford*, Linde Air Products Co.

Porosity in the Welding of Carbon Steel
by *Glenn W. Oyler* and *Robert D. Stout*, Lehigh University

9:30 A.M.—Field-Erected Structures
EMPIRE ROOM, CLEVELAND

Scale Effects in Notch Brittleness
by *Yoshio Akita*, Transportation Technical Research Institute

Effect of Subcritical Heat Treatment on the Transition Temperature of a Ship Plate Steel
by *E. B. Evans* and *L. J. Klingler*, Case Institute of Technology

Erection of the Welded Splayed Arch Bridge over the Rio Blanco River in Mexico
by *Camilo Piccone*, Civil Engineer and *Thomas C. Kavanagh*, New York University

Society for Nondestructive Testing

All Meetings at Hollenden Hotel, Cleveland

Monday, Oct. 19

9:00 A.M.—Welcoming Addresses
BALLROOM, HOLLENDEN HOTEL

9:00 A.M.—Educational Lecture Program
SUITE 316, HOLLENDEN

Purposes and Benefits of Nondestructive Testing
by *S. A. Wenk*, Battelle Memorial Institute

Sources of Defects Located by Nondestructive Testing
by *C. E. Betz*, Magnaflux Corp.

Radiography
by *R. G. Tobey*, Eastman Kodak Co.

Magnetic Particle Inspection
by *W. E. Thomas*, Magnaflux Corp.

2:00 P.M.—Radiography
BALLROOM, HOLLENDEN

X-Ray Focal Spot Measurement
by *D. T. O'Connor* and *D. Polansky*, Naval Ordnance Laboratory

A Preliminary Investigation on the Radiographic Visualization of Cracks
by *J. W. Dutli* and *G. H. Tenney*, Los Alamos Scientific Laboratory

Some Unusual Radiographic Problems
by *Michael D. Phillips*, *Merle L. Rhoten* and *Clara Kimmel*, Battelle Memorial Institute

An Investigation of Xeroradiography of Uranium With High Energy Sources
by *R. E. Cofield*, Carbide & Carbon Chemicals Co., Oak Ridge

2:00 P.M.—Educational Lecture Program
SUITE 316, HOLLENDEN

Testing With Ultrasonics
by *J. C. Smack*, Sperry Products, Inc.

Interrelation of Various Testing Methods
by *A. Cota*, A. O. Smith Corp.

Evaluation of Indications of Discontinuities
by *J. H. Bly*, X-Ray, Inc.

Tuesday, Oct. 20

9:00 A.M.—Betatron Radiography
BALLROOM, HOLLENDEN HOTEL

Characteristics of High Energy X-Rays
by *A. L. Pace*, General Electric Co.

Industrial Application of the 22-Mev Betatron
by *H. B. Norris*, Allis-Chalmers Mfg. Co.

Some Experimental Findings and Operating Practices in Betatron Radiography at Los Alamos
by *Norman C. Miller* and *John D. Steely*, Los Alamos Scientific Laboratory

Magnescanning (Betatron Magnification and Scanning Techniques)
by *A. N. Haig*, Allis-Chalmers Mfg. Co.

Further Investigations on the Industrial Use of the 31-Mev Betatron
by *R. W. Widerøe*, Brown Boveri & Co.

2:00 P.M.—Awards and Lester Honor Lecture
BALLROOM, HOLLENDEN HOTEL

Field Application of Radiography
by *Adair Morrison*, Arthur D. Little & Co.

4:00 P.M.—Business Meeting

Evening—Social Hour

Wednesday, Oct. 21

7:30 A.M.—Breakfast Meeting for Members of S.N.T.

9:00 A.M.—Isotopes and Problems of Nondestructive Testing Here and Abroad
BALLROOM, HOLLENDEN HOTEL

Radioisotopes in Nondestructive Testing
by *Paul C. Aeberold*, Isotope Division, Atomic Energy Commission

Application of Cesium^{137} to Industrial Radiography
by *Grover M. Taylor*, Los Alamos Scientific Laboratory

Program of Society for Nondestructive Testing

Wednesday Morning (Cont.)

Quality Control Through Radiography as Offered by the Independent Commercial Laboratory
by *Alan S. Kollock*, Industrial X-Ray, Inc.

Nondestructive Testing in Great Britain
by *Robert Bentley*, Ferranti Ltd.

Nondestructive Testing and the Society for Nondestructive Inspection in Japan
by *Uichi Hashimoto*, Tokyo University

The Gamma-Rays Machine
by *Paul R. Oakes*, Gamma Industries, Inc.

The Use of Iridium^{192} and Cobalt^{60} in Industrial Radiography
by *W. A. McCarthy*, Tracerlab, Inc.

2:00 P.M.—Ultrasonics
BALLROOM, HOLLENDEN HOTEL

Calibration Problems in Ultrasonics Testing
by *H. E. Van Valkenburg*, Sperry Products, Inc.

Inspection of Metals With Ultrasonics Surface Waves
by *Willard C. Minton*, Sperry Products, Inc.

Immersed Ultrasonics Inspection With Automatic Recording or Warning Signal
by *John C. Smack*, Sperry Products, Inc.

High Resolving Power Ultrasonic Flaw Plotting Through Use of Frequency Modulated Ultrasound
by *Don Erdman*, Electro Circuits, Inc.

Bi-Plexing Applications of the Improved Mark Eight Z-Ray Machine, a Dual Zonal Coordinating Scan Computor
by *H. H. Staats*, Magnaflux Corp.

Thursday, Oct. 22

9:00 A.M.—Magnetic Particle and Penetrant Inspection
BALLROOM, HOLLENDEN HOTEL

Recent Developments in Penetrant Inspection
by *A. Robinson*, General Electric Co.

Factors in Use of Black Light for Fluorescent Inspection
by *J. E. Clarke*, Magnaflux Corp.

Application of Magnetic Particle Inspection in Refineries
by *T. C. Wilson*, Sinclair Refining Co.

Role of Nondestructive Testing in Ford Motor's Quality Control Program
by *D. C. Hart*, Ford Engine & Foundry Div., Ford Motor Co.

1:30 P.M.—Eddy Current and Related Subjects
BALLROOM, HOLLENDEN HOTEL

Electronic Thickness Gage for Measuring the Thickness of Metallic Coatings
by *Abner Brenner*, National Bureau of Standards

Nondestructive Testing by Eddy Current Methods
by *Richard Hochschild*, Hanford Operations Office, A.E.C.

Practical Nondestructive Testing With Conductivity
by *William A. Cannon, Jr.*, Magnaflux Corp.

Special Libraries Association

Metals Division and Metals Section, Science-Technology Division

Thursday, Oct. 22

9:30 A.M.—Metal Fabrication—Methods and Literature
CLUB ROOM A, PUBLIC AUDITORIUM

Modern Methods for Joining Metals
by *P. T. Stroup*, Aluminum Co. of America

Abstracting and Indexing Sources for Literature on Metals and Metals Fabrication
by *Ellis Mount*, John Crerar Library

Services Available From Large Libraries
by *Esther M. Schlundt*, Purdue University

2:00 P.M.—Fundamentals of the Newer Metals
CLUB ROOM A, PUBLIC AUDITORIUM

Materials for Use at Elevated Temperatures
by *W. J. Harris, Jr.*, {Minerals and Metals Advisory Board, National Academy of Sciences}

Metallic Materials for Nuclear Reactors
by *Frank G. Foote*, Argonne National Laboratory

6:30 P.M.—Dinner With Cleveland Chapter S.L.A.
MATHER ROOM, HOTEL ALLERTON

Improvement of Reading Speed and Efficiency
by *Harold Johnson*, Case Institute of Technology

Friday, Oct. 23

10:00 A.M.—Technical Session
CASE INSTITUTE OF TECHNOLOGY

Operations Research as a Metallurgical Tool
by *C. West Churchman*, Case Institute of Technology

Techniques in Report Writing
by *Robert LeFevre Shutter*, Case Institute of Technology

12:30 P.M.—Luncheon
CROSBY'S RESTAURANT

2:00 P.M.—Inspection Trip to Warner and Swasey Co.

Taking the Mystery Out of Machine Tools
by *Warner Seely*, Warner & Swasey Co.

American Society for Metals

PRESIDENTS

ALBERT L. WHITE	1921	ALEXANDER H. d'ARCAMBAL	1932	HERBERT J. FRENCH	1943
FRANK P. GILLIGAN	1922	WILLIAM B. COLEMAN	1933	†MARCUS A. GROSSMANN	1944
†TILLMAN D. LYNCH	1923	†WILLIAM H. PHILLIPS	1934	KENT R. VAN HORN	1945
†GEORGE K. BURGESS	1924	BENJAMIN F. SHEPHERD	1935	†CHARLES H. HERTY, JR.	1946
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ZAY JEFFRIES	1929	JAMES P. GILL	1940	WALTER E. JOMINY	1951
†ROBERT G. GUTHRIE	1930	OSCAR E. HARDER	1941	JOHN CHIPMAN	1952
J. MITCHELL WATSON	1931	BRADLEY STOUGHTON	1942	RALPH L. WILSON	1953

SECRETARY

WILLIAM H. EISENMAN 1920

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†HENRY LE CHATELIER	†SIR ROBERT HADFIELD	ZAY JEFFRIES	A. E. WHITE
CECIL H. DESCH	†ELWOOD HAYNES	CHARLES F. KETTERING	WILLIS R. WHITNEY
†THOMAS ALVA EDISON	KOTARO HONDA	†JOHN ALEXANDER MATHEWS	

SAUVEUR ACHIEVEMENT MEDALISTS

†ALBERT SAUVEUR	1931	†ALBERT L. MARSH	1941	F. P. ZIMMERLI	1947
ZAY JEFFRIES	1935	BENJAMIN F. SHEPHERD	1942	†M. A. GROSSMANN	1949
WILLIAM B. CHAPIN	1936	†CHARLES H. HERTY, JR.	1943	CLARENCE E. SIMS	1950
HARRY W. McQUAID	1938	WALTER E. JOMINY	1944	ROBERT F. MEHL	1951
†STANLEY P. ROCKWELL	1939	ROBERT S. ARCHER	1945	JOHN CHIPMAN	1952
A. W. MACHLET	1940	EDGAR C. BAIN	1946	WILLIAM J. ENNOR	1953

HENRY MARION HOWE MEDALISTS

L. J. JANITZKY	1922	MAXWELL GENSAMER	1932	ROBERT F. MEHL	1939	CHARLES B. AUSTIN	1946
FRANCIS F. LUCAS	1924	JOHN F. ECKEL	1932	†M. A. GROSSMANN	1941	MAURICE C. FETZER	1946
HORACE H. LESTER	1925	JOSEPH V. EMMONS	1933	MORRIS ASIMOW	1941	W. A. PENNINGTON	1947
†E. C. LANGENBERG	1926	JOHN CHIPMAN	1934	S. F. URBAN	1941	J. W. SPRETNAK	1948
WESLEY P. SYKES	1927	†E. B. YENSEN	1935	W. A. SCHLEGEL	1942	R. L. AVERBACH	1949
OSCAR E. HARDER	1928	NICHOLAS A. ZIEGLER	1935	SHADBURN MARSHALL	1943	W. O. BINDER	1950
RALPH L. DOWDELL	1928	A. G. H. ANDERSEN	1937	B. A. FLINN	1944	C. M. BROWN	1950
†C. R. WOHRMAN	1929	ERIC R. JETTE	1937	TARNSHAW COOK	1944	RUSSELL FRANKS	1950
H. J. FRENCH	1930	JOSEPH WINLOCK	1938	J. A. FELLOWS	1944	R. J. LAZAN	1951
EDGAR C. BAIN	1931	E. W. E. LEITER	1938	HABA P. ANTIA	1945	E. M. MAHLA	1952
KARL HEINBUCHOFER	1931	C. S. BARRETT	1939	S. L. FLETCHER	1945	N. A. NIELSEN	1952
FRANCIS M. WALTERS	1932	GERHARD ANSEL	1939	MORRIS COHEN	1945	L. E. PORTER	1953
CYRIL WILLS	1932					P. C. ROSENTHAL	1953

THE GOLD MEDAL OF THE AMERICAN SOCIETY FOR METALS

ZAY JEFFRIES	1943	C. H. MATHEWSON	1947	EDGAR C. BAIN	1949	ROBERT F. MEHL	1952
EARLE C. SMITH	1945	F. C. FRARY	1948	PAUL D. MERICA	1951	GEORGE SACHS	1953

THE A.S.M. MEDAL FOR THE ADVANCEMENT OF RESEARCH

ROY A. HUNT	1943	R. E. ZIMMERMAN	1946	FRED H. HAGGERSON	1949	CLEO E. CRAIG	1952
†ROBERT C. STANLEY	1944	C. R. HOOK	1947	CHARLES E. WILSON	1950	H. G. RAICHELLER	1953
GERARD SWOPE	1945	†W. H. DOW	1948	GWILYM A. PRICE	1951		

CAMPBELL MEMORIAL LECTURERS

WILLIAM M. GUERTLER	1926	ANATOLE N. KRIVOBOK	1934	GEORGE B. FITTERER	1944
ZAY JEFFRIES	1927	HARRY W. McQUAID	1935	MAXWELL GENSAMER	1945
†W. H. HATFIELD	1928	JAMES P. GILL	1936	JAMES B. AUSTIN	1946
†ALBERT SAUVEUR	1929	WESLEY P. SYKES	1937	A. B. KINZEL	1947
†MARCUS A. GROSSMANN	1930	ALFRED L. BOEGEHOLD	1938	MORRIS COHEN	1948
†CHARLES H. HERTY, JR.	1931	EDMUND S. DAVENPORT	1939	EDGAR H. DIX, JR.	1949
EDGAR C. BAIN	1932	SAMUEL L. HOYT	1940	EARLE C. SMITH	1950
HERBERT J. FRENCH	1933	ROBERT F. MEHL	1941	C. H. DOBIE	1951
		JOHN CHIPMAN	1942	CYRIL STANLEY SMITH	1952
†Deceased		C. H. MATHEWSON	1943	DONALD S. CLARK	1953

What to See at the Metal Show

Exhibitors, Booth Numbers and Descriptions of Products in Ten Subject Categories

Producers of Metals and Alloys

EMERGENCE OF METALS and alloys once considered mere laboratory curiosities into full-fledged commercial acceptance may well prove to be the dominant theme of the 1953 National Metal Congress and Exposition. While steel and its many alloys continue to be the "backbone" of the metals industries, they are being supplemented by a host of new materials, tailor-made for specialized requirements of the electronic and atomic age.

Zirconium, beryllium, tantalum, cermets, carbides, boron alloys, borides—and, of course, titanium—are among the featured materials occupying prominent positions at this year's Metal Show. The producers are making extra efforts to portray to visitors the exact role of these relative newcomers to the metals field and to demonstrate how they are assisting industry in the improvement and refinement of a wide range of products.

Beyond the development of the new metal compositions themselves, concurrent progress has been made in techniques for precision rolling down to extremely thin gage. American Silver Co., Inc., for example, will show a variety of metals—tantalum, titanium, zirconium, beryllium copper, stainless steel and composites—rolled in widths up to 8 in. and as thin as 0.0005 in., with tolerance of ±0.0001 in.

Precision-rolled aluminum strip 0.016 in. thick will be deep drawn into shells by Scovill Mfg. Co. on a press which will draw cartridge brass into shells simultaneously alongside. The idea is to demonstrate the inherent physical characteristics of the aluminum, which minimize "orange peel" and "earing" effects. The aluminum strip coil being fed into the press, incidentally, will be 4170 ft. long, nonwelded and 1½ in. wide.

Thin-gage composite metals will be featured by the General Plate Division of Metals & Controls Corp. Heading the list are copper clad with stainless steel and copper-clad aluminum. Composite metals provide engineers with materials which give desirable combinations of physical properties, higher over-all strength, lower material weight, better fabricating characteristics, lower cost and savings in alloy consumption.

High-purity elemental boron and borides of tantalum, tungsten, titanium, chromium, zirconium, thorium, molybdenum, columbium, lanthanum, aluminum and silicon now are available from Cooper Metallurgical Associates in quantities large enough for use in production or in large-scale pilot plant development. Samples will be on display. Currently quoted prices on borides, in 100 to 500-g. amounts, range from 25c to $2 per g.

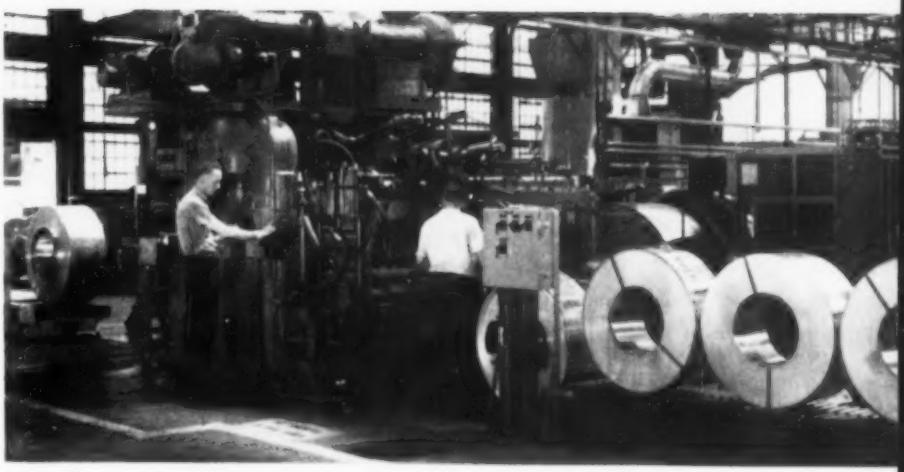
Among the scores of special alloys to be shown by P. R. Mallory & Co., Inc. will be Mallory 1000, a homogeneous "heavy" alloy of tungsten, nickel and copper, produced by powder metallurgy methods and formed into nonsymmetrical shapes by contour pressing. It has three broad fields of application: for counterbalancing where space is limited (as in self-winding wrist watches); as a rotating inertia member (gyroscopes), and as a shielding material for protection of personnel from X-rays, radium and secondary radiation products.

Mallory also will have an array of silver and platinum alloys shaped into contact points for such equipment as industrial relays, generator cutouts, starting switches, thermostats, signaling devices, appliances, surgical devices and vending machines.

The American Brass Co.'s exhibit at the Metal Show, will feature "Formbrite" drawing brass, which is claimed to be stronger, harder and of greater elastic limit than the usual drawing brasses and yet retains high ductility for forming, drawing and embossing. One of its principal qualities is its unusual polishing characteristics, and to illustrate this, a four-station automatic index buffer will be in op-

eration polishing cups of Formbrite. In addition, a large number of items made of this alloy, plain and plated, will be on display.

A new melting process for titanium, known as "Method S" and first announced during the past summer by Mallory-Sharon Titanium Corp., will highlight the exhibit of this producer. The technique combines elements of both arc and induction melting, using a copper crucible and a titanium electrode. Yields are said to be increased and carbon content of the melt can be controlled precisely. The company, by the way, now has capacity for producing 1000 tons of titanium annually.



Coil of Aluminum Strip Is Being Threaded Into New Cold Rolling Mill at Scovill Mfg. Co. Cold rolled coils run over 4100 ft. in length

Display of the Titanium Alloy Mfg. Division of National Lead Co. is again going to emphasize this producer's development work with the metal zirconium. Metallurgical interest in zirconium was heightened by the extensive symposium on the subject at the recent Western Metal Congress, much of which was reproduced in *Metal Progress* for May. Suggested applications for the metal, outside the field of atomic energy, include grid wires in vacuum tubes, parts of discharge tubes exposed to high

Classified List of Exhibitors and Booth Numbers

Stainless and Corrosion Resistant Steels

Alloy Engineering & Casting Co.—2661
Alloy Metal Wire Co., Inc.—2723
American Cast Iron Pipe Co.—2233
American Silver Co., Inc.—1305
Arwood Precision Casting Corp.—1428
Crucible Steel Co. of America—241
Fahralloy Co.—2571
Firth Sterling Inc.—912
General Alloys Co.—251
International Nickel Co., Inc.—332
Metals & Controls Corp., General Plate Division—1029
Misco Corporation—211
Ohio Steel Foundry Co.—1116
Rigidized Metals Corp.—430
Ryerson & Son., Inc., Joseph T.—205
Standard Alloy Co., Inc.—1830
Timken Roller Bearing Co.—951
Universal-Cyclops Steel Corp.—2116
Vacuum Metals Corp.—2007

Light Metals and Alloys

American Non-Gran Bronze Co.—2515
American Silver Co., Inc.—1305
Arwood Precision Casting Corp.—1428
Crucible Steel Co. of America—241
Firth Sterling Inc.—912
Malayan Tin Bureau—811
Metals & Controls Corp., General Plate Division—1029
Rigidized Metals Corp.—430
Scovill Mfg. Co.—1724, 2112
Vacuum Metals Corp.—2007
Vanadium Corp. of America—1325

Heavy Nonferrous Metals and Alloys

American Brass Co.—141
Arwood Precision Casting Corp.—1428
Beryllium Corp.—1735
Black Drill Co., Inc.—1119
Bridgeport Brass Co.—807
Brush Beryllium Co.—433
Chase Brass & Copper Co.—1020
Firth Sterling Inc.—912
Mallory & Co., Inc., P. R.—1626
Mallory-Sharon Titanium Corp.—1626
Metals & Controls Corp., General Plate Division—1029
Scovill Mfg. Co.—1724
Tin Research Institute, Inc.—815
Titanium Alloy Mfg. Division, National Lead Co.—2409
Union Carbide and Carbon Corp.—1508
Vacuum Metals Corp.—2007

Steels (Plain and Alloy)

American Cast Iron Pipe Co.—2233
American Silver Co., Inc.—1305
Arwood Precision Casting Corp.—1428
Cooper Metallurgical Associates—2670
Crucible Steel Co. of America—241
Fahralloy Co.—2571
Firth Sterling Inc.—912
International Nickel Co., Inc.—332
Rigidized Metals Corp.—430
Ryerson & Son, Inc., Joseph T.—205
Universal-Cyclops Steel Corp.—2116
Vacuum Metals Corp.—2007
Vanadium-Alloys Steel Co.—1401

High-Temperature Alloys

Alloy Engineering & Casting Co.—2661
Alloy Metal Wire Co., Inc.—2723
American Brake Shoe Co.—305
American Cast Iron Pipe Co.—2233
American Silver Co., Inc.—1305
Arwood Precision Casting Corp.—1428
Crucible Steel Co. of America—241
Electro-Alloys Division, American Brake Shoe Co.—305
Fahralloy Co.—2571
Firth Sterling Inc.—912
General Alloys Co.—251
International Nickel Co., Inc.—332
Kanthal Corp.—2229
Metals & Control Corp., General Plate Division—1029
Misco Corporation—211
Ohio Steel Foundry Co.—1116
Rigidized Metals Corp.—430
Standard Alloy Co., Inc.—1830
Timken Roller Bearing Co.—951
Union Carbide and Carbon Corp.—1508
Universal-Cyclops Steel Corp.—2116
Vacuum Metals Corp.—2007

Producers of Metals and Alloys (Continued)

temperatures, electrolytic condensers for rectifiers, high-intensity lamp filaments and electrodes in fluorescent lamp tubes. Zirconium in hot rolled bar form now carries a base price of $27 per lb.

New applications of beryllium in the realm of ferrous alloys, along with samples of Beryldur, a new beryllium-copper alloy for broader utilization, will occupy top spots at the Metal Show exhibit of Beryllium Corp.

There has been no diminution of interest in metals to withstand the high-temperature blasts of jet engines, as a trip through the Metal Show will reveal. Every extra 100° that can be tacked on to a jet's hot-section temperature means a few hundred pounds more thrust, so the search for metals to do the job continues apace.

Firth Sterling Inc. has been doing pioneer work in this direction and has geared its new laboratory facilities accordingly. Some results of recent progress in titanium carbides and cermets (mixtures of ceramics and metals) will be on tap for Metal Show visitors. Firth Sterling, incidentally, has obtained exclusive U. S. license for manufacture and marketing of titanium carbide-base cermets developed by Hard Metal Tools Ltd., Coventry, England, and by Metallwerk Plansee, Reutte, Austria.

Cutting production costs through faster machining can be accomplished in two principal ways—stronger and tougher tools, or stock which machines more freely. Joseph T. Ryerson & Son, Inc. approaches the problem from the latter standpoint and offers a diversified line of free-cutting steels, in carbon, alloy and stainless grades. Heading the list is an openhearth lead-bearing steel, called Ledloy, which can be machined at surface speeds of 300 fpm. or better. On display by Ryerson will be typical parts produced on automatic screw machines from this steel, as well as from many other free-cutting grades, both standard and special.

Where resistance to corrosion, wear or fatigue is an important consideration in product design, silicon bronze or silicon-aluminum bronze alloys may be the answer. Bridgeport Brass Co. plans to demonstrate in its exhibit the numerous advantages of high-strength silicon bronze alloys for cold heading and upsetting of screw products.

Metals Manufacture

SINCE ALL METAL PRODUCTS, with the exception of powder metal compacts, originate in the cast form, the processing and treatment of virgin cast metal, whether for ingots destined for wrought shapes or for foundry castings, becomes of primary concern. Ample evidence of new contributions to both ferrous and nonferrous metals manufacture will be unfolded to Metal Show visitors.

How steelmakers can produce stainless steel of extremely low carbon content without modifying furnace or melting practice will be explained by Vanadium Corp. of America. A new low-carbon ferrochromium, made by a unique electric furnace method, appears to provide a solution, since it combines a normal silicon content with a high chromium-to-carbon ratio. A $3.5 million plant expansion is now under way for stepping up output of this type of ferrochrome.

Another aid to stainless steel producers is Vanadium's multiple-element Grainal alloys, which tend to alleviate hot shortness, thereby cutting conditioning costs and increasing tonnage. These alloys have become well known also in the melting of boron steels, now being produced at a rate of over a million tons a year.

In the family of so-called "needling" alloys are those used for the nodularizing treatment of cast iron. The strength advantages of the nodular or ductile irons have brought significant increases in their production. (See Critical Points in *Metal Progress* for September, p. 82.)

High purity and increased yields are twin goals aimed for by all metal-producing shops. To assist steelmakers and foundrymen in their realization, Exomet, Inc. has developed a highly exothermic material called "Ingotherm". It generates a temperature of about 4200° F. when applied to the hot top or head of an ingot, reducing the amount of feed metal needed in the hot top by retarding the formation of bridging within the ingot. It is claimed the material will increase yields on 25x25-in. ingots as much as 12%. The amount to be added varies with ingot size and analysis, but is roughly 1% of the ingot weight. Similar types of exothermic additives are being offered to steel foundries to increase casting yields.

Melting of gas-free, high-purity metals in limited quantities under vacuum is a new procedure commercially, the results of which will be unveiled by Vacuum Metals Corp. This exhibit will show, among other things, vacuum-cast precision bearings of 52100 steel. The finished bearings show improved fatigue resistance and fewer rejects in processing. Vacuum-cast metals likewise are finding applications in the electronics industry for power-tube elements. Exceptional purity, carefully controlled composition and freedom from out-gassing are the advantageous factors.

Parent company of Vacuum Metals, the National Research Corp., will show equipment for vacuum fusion analysis of gases in metals, of particular value in assessing oxygen, nitrogen and hydrogen contents. This equipment is also a valuable tool in titanium research and production.

Nonferrous foundrymen will be intrigued by the display of gypsum cements by the United States Gypsum Co. These plaster materials have been adapted to pattern and model making as well as to cope and drag molds for certain types of nonferrous products such as art casting, statuary and the like. Plaster molds are said to be ideally suited to castings of low melting point alloys in the lead-zinc group, aluminum alloys, and as insulating riser sleeves for low-lead brasses and bronzes.

In the forging field, as in most other classifications of metalworking, the trend is to continuous operation and full mechanical controls. Heating equipment, presses, materials handling devices and related accessories all are being redesigned toward this end, and the Show will reflect a considerable degree of this progress. Readers of *Metal Progress* may recall the description (February) of how one of the large automobile companies has set up a new plant to press forge crankshafts on a continuous line at a rate three times the former speed and at a cost saving of 25%.

Classified List of Exhibitors and Booth Numbers

Mill Equipment

American Brake Shoe Co.—305
Fahralloy Co.—2571
National Diamond Laboratory—2752
Sly Mfg. Co., W. W.—2560

Ferro-Alloys

Climax Molybdenum Co.—1515
Fahralloy Co.—2571
International Nickel Co., Inc.—332
Titanium Alloy Mfg. Division, National Lead Co.—2409
Union Carbide and Carbon Corp.—1508
Vanadium Corp. of America—1325

Die-Casting Machines

Kux Machine Co.—1419

Melting Furnaces and Refractories

Ajax Electrothermic Corp.—221
American Gas Association—2645
National Research Corp.—2007
North American Mfg. Co.—1134
Norton Company—1933
Scientific Electric Division, "S" Corrugated Quenched Gap Co.—2402

Forging Equipment

American Gas Association—2645
Surface Combustion Corp.—321
United States Gypsum Co.—707

Foundry Processes, Equipment and Supplies

Allied Chemical & Dye Corp., General Chemical Division—2567
American Wheelabrator & Equipment Corp.—2629
Allison Co.—2561
Arcair Co.—710
Buehler, Ltd.—115
Cities Service Oil Co.—919
Cleveland Process Co.—612
Exomet, Inc.—605
Pyrometer Instrument Co., Inc.—939
Sly Mfg. Co., W. W.—2560
Tincher Products Co.—2552
Titanium Alloy Mfg. Division, National Lead Co.—2409
United States Gypsum Co.—707

Metal Components

(Refining, Casting and Forging)

SEMIFABRICATED or completely finished parts, as distinguished from mill products ready for further fabrication, are the items under consideration in this section. Certain subjects defy ready classification and it may be that these so-called borderline cases are included under "Metals and Alloys".

Undoubtedly, the greatest impetus to this segment of the metalworking industry has been from the demand by the Armed Forces for not only complex forms and shapes but—to compound the difficulties—that these be of difficult-to-work alloys. Past issues of *Metal Progress* have described some of these difficulties in fabricating. For example, the "Critical Point" in the May 1953 issue highlights such problems in the manufacture of wave guides used in mobile radar equipment, and the article "Metallurgical Aspects of Large Pressings, Forgings and Extrusions for Aircraft" in March

explains some of the metallurgical requirements that will have to be met in the Air Force's large-press program.

Castings—Sustained high interest in ductile or nodular cast irons for new applications is still very much in evidence, according to the editorial coverage given this alloy by the technical and engineering publications. At the Metal Show the American Brake Shoe Co. will display nodular iron castings which it produces under the trade name "Ductalloy". Three grades are available; ferritic, pearlitic, and austenitic. The pearlitic grade, Ductalloy 80, has tensile values comparable to those of malleable cast iron A. S. T. M. 60003, greater hardness, good toughness, castability, machinability, and wear resistance. Incidentally, the machinability of ductile iron was evaluated in the U.S. Air Force Machinability Research Program. (This subject was reported also in "Fast Cutting of Metals by Better Mechanical and Metallurgical Engineering", *Metal Progress* for June 1952, p. 95.) Its wear resistance was studied by the National Advisory Committee for Aeronautics; the reports rated nodular iron to be very good in these respects. This company also produces castings of Meehanite and of ABK Metal (nickel-chromium-iron alloy), the latter being especially suited to applications involving a high degree of abrasion.

Speaking of new alloys, Janney Cylinder Co. is centrifugally casting Armco iron for components in fractional horsepower motors where high magnetic permeability is desired, and is using silicon-iron bronze for blanks which are forged into cages for ball and roller bearings used in jet aircraft. Another exhibitor of centrifugal castings is Shenango-Penn Mold Co. This company produces bars and tubes, as well as items such as rings, bushings and other cylindrical items, of nonferrous alloys, Meehanite, Ni-Resist and special iron alloys. American Cast Iron Pipe Co. will be at the show to tell visitors how its quarter century of experience in making centrifugal castings can be employed in the mass production of identical parts requiring the advantages offered by this method of production.

A description of the Antioch process, together with exhibits of aluminum castings made by it, will be available at the booth of Morris Bean & Co. (See also *Metal Progress* for February 1953, p. 97.) The process uses molds made of a special mixture of sand and gypsum and these permit the production of extra-large castings (up to 96 in. diameter) while retaining dimensional accuracy and surfaces that are comparable to those on castings made from plaster molds. An interesting sidelight on this process—as well as on the precision or lost-wax method—is that they first found use in the delicate work required for casting of "objets d'art".

The high favor held for these techniques by the skilled craftsman was, of course, on account of the high fidelity of detail reproduced in the castings.

Classified List of Exhibitors and Booth Numbers

Forgings

American Brass Co.—141
Chase Brass & Copper Co.—1020
Crayton Tee Bolt Co.—434
Crucible Steel Co. of America—241
Firth Sterling Inc.—912
International Nickel Co., Inc.—332
National Cored Forgings Co., Inc.—109
Ohio Seamless Tube Co.—1834
Union Carbide and Carbon Corp.—1508

Castings

Alloy Engineering & Casting Co.—2661
American Brake Shoe Co.—305
American Cast Iron Pipe Co.—2233
American Non-Gran Bronze Co.—2515
Austenal Laboratories, Inc., Microcast Division—836
Bean & Co., Morris—2722
Casting Engineers, Inc.—2350
Chase Brass & Copper Co.—1020
Crucible Steel Co. of America—241
General Alloys Co.—251
Electro-Alloys Division, American Brake Shoe Co.—305
Fahralloy Co.—2571
International Nickel Co., Inc.—332
Howard Foundry Co.—1623
Janney Cylinder Co.—2522
Lynchburg Foundry Co.—2461
Misco Corporation—211
Ohio Steel Foundry Co.—1116
Precision Castings Co., Inc.—509
Precision Metalsmiths, Inc.—2134
Shenango-Penn Mold Co.—2622
Union Carbide and Carbon Corp.—1508

Tubing and Other Mill Shapes

American Brass Co.—141
American Cast Iron Pipe Co.—2233
American Nickeloid Co.—2721
Babcock & Wilcox Co., Tubular Products Division—212
Bridgeport Brass Co.—807
Chase Brass & Copper Co.—1020
Crucible Steel Co. of America—241
Flexonics Corp.—616
H & H Tube & Mfg. Co.—2216
International Nickel Co., Inc.—332
Ohio Seamless Tube Co.—1834
Parker Machine Co., Inc.—1932
Precision Shapes, Inc.—414
Superior Tube Co.—1014
Union Carbide and Carbon Corp.—1508

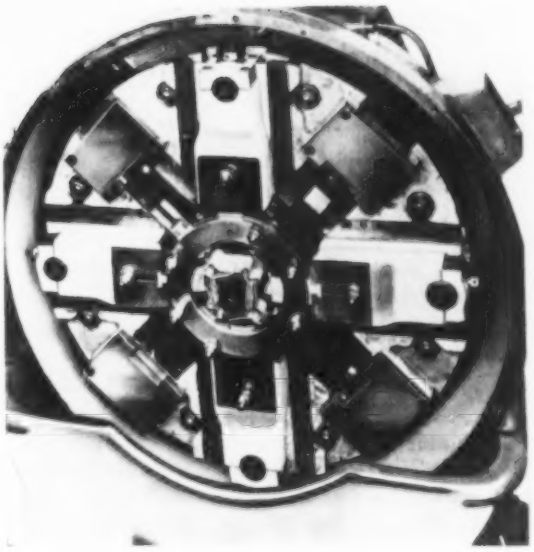
Stampings

American Brass Co.—141
Chase Brass & Copper Co.—1020
HPL Mfg. Co.—933
Heintz Mfg. Co.—1001
Metals & Controls Corp., General Plate Division—1029
Union Carbide and Carbon Corp.—1508
Waldes Kohinoor, Inc.—2239

Powder Metals and Parts Production

Adamas Carbide Corp.—2550
Alpha Corp.—2602
American Brake Shoe Co.—305
Amplex Division, Chrysler Corp.—2212
Baldwin-Lima-Hamilton Corp.—1139
Firth Sterling Inc.—912
Mallory & Co., Inc., P. R.—1626
Precision Shapes, Inc.—414
Titanium Alloy Mfg. Division, National Lead Co.—2409
Union Carbide and Carbon Corp.—1508
Vanadium-Alloys Steel Co.—1401
Yale & Towne Mfg. Co., Powdered Metals Division—810





Increases of 300% and More in the Production of Formed Wire Parts Are Said to Be Obtainable With the "Wirematic" Wire Forming Machine to Be Shown by Parker Machine Co., Inc. Depending on size and shape of the parts to be formed, the tooling can be arranged so that two to four parts are produced during each revolution of the arbor. At right is shown a set-up for making four screen door hooks with each revolution to give a production of 100 parts per min. The wire is drawn through straightening rolls and winds itself around the coiling section of a rotating arbor. As each winding of the wire coil proceeds along the arbor, it reaches several forming stations where it is gradually pressed into the desired shape as illustrated above

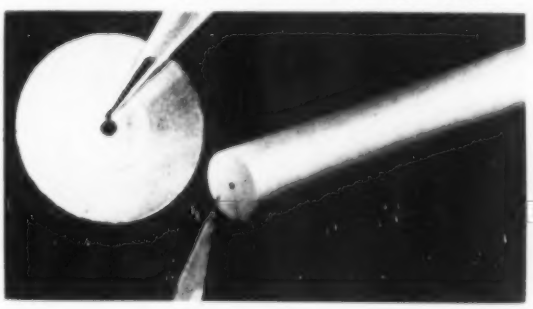
Precision Metalsmiths, Inc. will demonstrate how these expendable wax patterns are made in machined steel dies. Microcast Division, Austenal Laboratories, Inc. will exhibit investment castings of plain carbon and low-alloy steels, high-temperature alloys and a limited range of toolsteels, embodying close tolerances, smoothness of surface and intricate contours.

Die castings, which are being used in increasing quantities for the stator and rotor members of automatic transmissions for automobiles, will be shown by Precision Castings Co., Inc. Here again, military products, such as the detonating fuses for 60-mm. and 81-mm. mortar shells which this company makes, are an important stimulus to the productive capacity of this method of manufacture.

The evolution of economical cold extrusion of steel has been hailed by the technical press as one of the major technological developments of the past quarter century—perhaps rightly so. The Heintz Mfg. Co., one of the pioneers in this field (they just completed a multi-million dollar cold extrusion installation for the production of naval ordnance) will display not only a variety of cold extruded parts of steel, but also stampings such as air-conditioner parts, domestic plumbing fixtures and hardware, and automotive components. Another exhibitor of stampings will be Waldes Kohinoor, Inc., a maker of seemingly unlimited kinds of retaining rings. They also manufacture a grooving tool for cutting recesses in housings and bores to take the rings.

Tubular and special shaped products in most commercial alloys and metals will be featured by a number of exhibitors. These items for the automotive, heating, air-conditioning, plumbing and refrigeration industries—to mention a few—seem to be designed in shapes, contours and tapers as though in challenge to the abilities of the fabricator. H & H Tube and Mfg. Co. will show some of these complex parts, together with tubing of various cross-sectional forms. One panel of the exhibit of Superior Tube Co. will have representative samples of tubing in all sorts of alloys for the aircraft, diesel, electronics, chemical and metalworking industries. Included also will be samples of commercially pure and alloy titanium tubing, together with samples of the smallest tubing ever drawn from commercially pure titanium, measuring only 0.0455 in. outside diameter and having wall thickness of 0.00225 in. Precision Shapes, Inc. will have at its booth bar-length components of various profiles made by the company's continuous milling process to customer specifications.

Super-Pressure Tubing, Double-Wall Type, Made by Superior Tube Co. From Two Thinner-Walled Tubes, One Drawn Over the Other



Tooling . . . . .

IT SEEMS THAT whatever the problem a visitor to the Metal Show might have as to machine tools, tooling or associated equipment, he will in all likelihood find an answer from at least one of the many exhibitors of these items. The types of equipment will range from such highly specialized units as the automatic drilling and tapping machine for transmission cases made by Zagar Tool, Inc., to the general-purpose machine being introduced by Newage International, Inc. The former has two stations to drill and tap six power take-off holes on each side of seven different transmission cases, while the latter (called the Rindis Universal) performs more than 50 different operations. This relatively small machine is adaptable to cylindrical, internal and external grinding, various milling, drilling and boring operations, slotting, band sawing, and turning, as well as lapping and polishing.

About 100 years ago, at the time the forerunner of the modern turret lathe was built, the major concern of the industry was the development of what is now called interchangeable manufacture to meet the demand of industrial expansion; today the problem—to meet essentially the same demand—is the development of machinery which eliminates in nearly all phases of manufacturing activity the expensive slowness of manual effort, as in loading, feeding, and cycling.

Some of these manual functions have been made automatic in most of the modern machine tools so that the workpiece goes through the full processing cycle with minimum attention from the operator. However, much remains to be done with the automatization of material between processing stations or machines, and with the initial feeding and positioning of work in the machines. A significant start has been made in this direction, but because not all metalworking plants can hope to install such fully automatic production lines, their savings in handling operations must come from more modest advancements. An example of this is the approach used by Precision Welder & Flexopress Corp. Manpower requirements are reduced by means of an automatic feed on its Model C-30 stamping press. The feed rolls, which will handle materials ranging from 0.002-in. thick foil to heaviest gages within its 30-ton capacity, are built as an integral part of the machine for closest relationship to the die. Kurt Orban Co., Inc. will show for the first time the new Lindner LB15 jig borer equipped with a "preselective autopositioner" that permits making precise first settings for each consecutive hole on a workpiece. By means of an optical projection system, the operator can preselect the table position for the next hole while a boring operation is in progress. Working in conjunction with the optical projection system is a photo-electric zero indicator which comes to rest the instant the image of the desired location line approaches the center of the reticle.

Another means of slicing production time and cost in a wide variety of machining operations is through the use of special shop-designed machines built around "package" power units. A number of air-powered hydraulic power units for use in drilling, reaming, spot facing and hollow milling will be displayed by the Rockwell Mfg. Co. Bridging the gap between the standard drill press and the special-purpose machine is the Magna Drill (offered by Magna Engineering Corp.) for fast setups for multiple drilling or tapping in more than one plane. Essentially, the machine consists of a standardized, individually powered, adjustable drillhead assembly mounted on a system of steel tubes by means of a sliding joint which permits a 360° rotation of the head. Any number of units may be individually mounted to the table in horizontal, vertical or angular planes. The Clausing Division of Atlas Press Co. will show some of its drill presses which use a gear-driven power feed to keep the feed in direct relation to drill speed. Boice-Crane Co. has a combination contour saw and band filer for cutting and shaping items such as special wrenches, cams, stacked parts of irregular shape, blanking and trimming dies and other articles used in laboratories and tool, die and machine shops. A smaller version of a cutting saw for use as a hand tool is the "Little Wonder Nibbler" which cuts metal up to 14 gage. The tool, made by Fenway Machine Co., also has a punch and die arrangement for cutting holes in tubes and ducts without damaging their contour.

"Kroslock" is a new face-milling cutter being introduced by Motch & Merryweather Machinery Co. which has three basic members—body, blade and wedge. Mating cross-serrations on one side of the body channel and similar cross-serrations on the blade hold the blade rigidly to the body. The wedge is driven between the smooth side of the body channel and the blade after the serrated pattern is mated. Blades are either high speed toolsteel or tipped with cemented carbide.

Tools and associated equipment will be given as much attention as the machine tools which use them. Thus Allison Co. will feature cut-off wheels

designed specifically for cutting titanium and heat resistant alloys used in jet engines. Adamas Carbide Corp., will have a pill press in operation, and exhibit tools made of its new grade of tungsten carbide, together with flow charts detailing its manufacture. These tools have taken cuts of ⅛ to ¼ in. at feeds ranging from 0.015 to 0.068 in. per revolution and at speeds from 68 to 600 surface ft. per min. In the way of special toolsteels will be the exhibit by A. Milne and Co. of its "CMW" hollow die steel and high-speed hollow die steel. National Diamond Laboratory will display its industrial wheel dressers set in a new powdered bond containing titanium for more tenacious holding of the diamond.

A subject closely related to tool grinding and dressing is that of cooling during such operations. A. P. de Sanno & Son, Inc., will demonstrate its method of using carbon dioxide as a coolant in the grinding of carbide tools on its Radiac wheels of so-called "open structure". To assist toolmakers in producing accurate tools and related parts, the Leitz toolmaker's microscope WMH to be exhibited by George Scherr Co., Inc. has the features of an ordinary toolmaker's microscope plus what they call an intermediate image system which incorporates a total of 88 master charts containing radii, angles, screw threads, against which work is compared.

One of the newer lubricants which has received a fair share of glowing reports regarding its superior lubricity is pure molybdenum disulphide. It has exceptional chemical stability and is ideally suited for applications involving open gears, splined shafts, and reciprocating parts in general which have the tendency to gall, fret, weld or wear excessively. The Alpha Corp. has devoted considerable effort to obtain molybdenum disulphide that is virtually free of abrasive constituents. This highly purified form is marketed under the name Molykote. As a solid or dry lubricant, it is particularly suitable where liquid films cannot be maintained for reasons of heat or cold and where extreme pressures are involved. This lubricant is said to withstand a range of temperatures from –90 to 750° F. and pressures in excess of 400,000 psi. Also among the new lubricants

Classified List of Exhibitors and Booth Numbers

Toolsteels and Tool Materials

Adamas Carbide Corp.—2550
Crucible Steel Co. of America—241
DoAll Co.—1037
Firth Sterling Inc.—912
Milne & Co., A.—502
National Diamond Laboratory—2752
Timken Roller Bearing Co.—951
Union Carbide and Carbon Corp.—1508
United States Gypsum Co.—707
Universal-Cyclops Steel Corp.—2116
Vanadium-Alloys Steel Co.—1401

Cut-Off Equipment

Allison Co.—2561
American Chain & Cable Co., Inc., Andrew C. Campbell Division—1716
Arcair Co.—710
Crucible Steel Co. of America—241
De Sanno & Son, Inc., A. P.—2101
DoAll Co.—1037
Fenway Machine Sales Co., Inc.—423
Kalamazoo Tank & Silo Co., Machine Tool Division—2447
Motch & Merryweather Machinery Co., Cutting Tool Mfg. Div.—1929
Norton Company—1933
Rockwell Mfg. Co., Delta Power Tool Division—1310
Stone Machinery Co., Inc.—2238

Machine Tools and Accessories

Acme Tool Co.—726
Adamas Carbide Corp.—2550
American Pullmax Co., Inc.—2416
Atlas Press Co.—2457
Bath Co., Cyril—1603
Black Drill Co., Inc.—1119
Boice-Crane Power Tools—2672
Continental Tooling Service, Inc.—1729
Crane Packing Co.—2416
Crayton Tee Bolt Co.—431
DoAll Co.—1037
Electro-Arc Mfg. Co.—2461
Elox Corp. of Michigan—2660
Flexonics Corp.—616
H & H Research Co.—720
Kalamazoo Tank & Silo Co., Machine Tool Division—2447
Kux Machine Co.—1419
Lapeer Mfg. Co.—1208
Lee Co., K. O.—2441
Magna Engineering Corp.—2540
Martindale Electric Co.—2616
Miller Motor Co.—1217
Motch & Merryweather Machinery Co., Cutting Tool Mfg. Div.—1929
Nelco Tool Co., Inc.—2760
Newage International, Inc.—411
Nicholas Equipment Co.—2324
Orban Co., Inc., Kurt—2308
Parker Machine Co., Inc.—1932
Porter-McLeod Machine Tool Co., Inc.—2528
Production Machine Co.—1709
Rockwell Mfg. Co., Delta Power Tool Division—1310
Scherr Co., Inc., George—626
Sheldon Machine Co., Inc.—1629
South Bend Lathe Works—820
Starrett Co., L. S.—2603
Torit Mfg. Co.—1641
Union Carbide and Carbon Corp.—1508
Versa-Mil Co.—1230
Vlier Engineering, Inc.—1112
Whistler & Sons, Inc., S. R.—2024
Willey's Carbide Tool Co.—1315
Zagar Tool, Inc.—2330

Cutting Oils and Forming Lubricants

Aldridge Industrial Oils, Inc.—702
Alpha Corp.—2602
Cities Service Oil Co.—919
DoAll Co.—1037
De Sanno & Son, Inc., A. P.—2101
Houghton & Co., E. F.—1019
Johnson & Son, Inc., S. C.—2546
Motch & Merryweather Machinery Co., Cutting Tool Mfg. Div.—1929
Pennsylvania Salt Mfg. Co.—1001
Shell Oil Co.—1944
Tide Water Associated Oil Co.—2316

Punches and Dies

Adamas Carbide Corp.—2550
Bath Co., Cyril—1603
Continental Tooling Service, Inc.—1729
Timken Roller Bearing Co.—951
Union Carbide and Carbon Corp.—1508
Whistler & Sons, Inc., S. R.—2024
Willey's Carbide Tool Co.—1315
Vanadium-Alloys Steel Co.—1401

Presses and Brakes

Baldwin-Lima-Hamilton Corp.—1139
Bath Co., Cyril—1603
Brainard Steel Division, Sharon Steel Corp.—2040
Duke Engine Co.—2453
DoAll Co.—1037
Kux Machine Co.—1419
Precision Welder & Flexopress Corp.—1924

Tooling (Continued)

is Johnson's No. 130 Wax-Cool, a water soluble coolant which will provide lubrication at pressures up to 200,000 psi. and at temperatures up to 450° F. Other products being exhibited by S. C. Johnson & Son, Inc. include Wax-Cut for use in automatic screw machines, gear cutters, gear shapers and grinders; Stik-Wax used in drilling, sawing, tapping and grinding; and Wax-Draw, which is available either as a nondrying lubricant or a dry-film lubricant for use in drawing and forming operations.

Machines for the newer methods of production will be in strong evidence, as for example the contour, bend forming and radial draw forming machines made by Cyril Bath Co. Radial draw forming is receiving increased application in plants manufacturing components for jet engines because this process permits fast production of circular parts of light cross section, yet dimensions can be held closely and wastage of metals is at a minimum. The effect on the metal of the radial draw forming operation is not greatly different from that obtained when the metal is drawn in a press. This forming operation is essentially the same as stretch forming, with the exception that an auxiliary hydraulically actuated ram engages a hard bronze shoe against the metal to be stretched so as to compress it between the shoe and the revolving die. The function of the ram is to maintain the cross sectional shape accurately while a piece is being stretch formed. The rotation of the table which carries the round die compels the part to be formed to the shape of the die and its diameter.

Kux Machine Co. and Baldwin-Lima-Hamilton Corp. will display powder metal presses. The former will have at its booth a 30-ton unit capable of making powdered parts up to 4 in. in diameter and a 3-in. maximum depth of die fill. The machine is completely automatic in operation and requires only occasional filling of the supply hopper for continuous production. The Baldwin-Lima-Hamilton machine, known as model C, has a compacting pressure capacity of 100 tons.

Heat Treating . . . .

When one compares the heat treating of today with the practices of that period some 35 years ago when it was largely a kind of a black magic and advanced alchemy, it is truly remarkable that so much progress has been made—and often against militant ignorance. It would be safe to say that this progress has been in small but continuous spurts, rather than in great and spectacular rushes.

There are examples of such small but significant advances in heat treating during the past year, most noteworthy being the steel mill installation for heating alloy and stainless steel billets for the manufacture of tubing and shapes by the extrusion process. Attempts have been made in former years to utilize salt baths for heating steel blanks for forging, but the first large production installations were made in 1952. A number of salt baths have been installed by an automobile manufacturer for heating alloy steel plates for forming. Significant also is the Aldip process of coating steel with aluminum (developed by the General Motors Research Division and described in the July 1953 issue of *Metal Progress*, p. 85) which has been placed in operation in a number of commercial installations during the past year. To a considerable extent, these large-scale operations have been made possible by two rather recent improvements in salt bath furnaces: Life of refractory pots has been increased considerably as a result of better refractories, and electrode life has been increased by the development of the submerged electrode so that they last for months rather than weeks as formerly.

Martempering and austempering are meeting many of the tough requirements for the heat treating of ordnance material. Thus, the ballistic requirements of the new armor-piercing shot are much more severe than in World War II; these are being martempered to avoid any danger of cracking and at the same time develop the hardness desired in these highly alloyed steels. The considerable internal pressure developed in the tubular body of the bazooka at the time of firing demands a tube of consistently uniform physical properties after heat treatment, and such uniformity is being obtained by use of a modified austempering treatment. Installations for these applications were made recently by Ajax Electric Co., and information on these and other problems will be available from the firm's representatives at its booth.

While on the subject of heat treating of ordnance

items. Harmon & Co. will explain at its booth the principles and practices of using jet-combustion rotary forging and heat treating furnaces for shells, cartridge cases, bombs, rockets and related items of national defense.

The Gas Machinery Co. will exhibit and have in operation its "Gasmaco" furnace for the heat treatment of high speed toolsteels. The furnace uses radiant tubes of silicon carbide and has provision for the introduction of a selected heat treating atmosphere. Continental Industrial Engineers, Inc., will describe to visitors their automatic plugmill reheat furnace which reheats tubes after the piercing operation to obtain thermal uniformity from the leading end of the pierce to the trailing end. This unit, together with a number of others manufactured by the company, has been installed in a large steel mill in the middle west.

The shortage of tungsten and the high cost of high speed tungsten steel have brought attention to the molybdenum types of high speed steel. These do present some hardening problems. The Sentry Co. will have a furnace in operation in its booth demonstrating the hardening of molybdenum steel tap blanks. Facilities will be available for the hardening of sample tools that may be brought in by interested visitors.

A relatively wide range of process applications is claimed for the "Allcase" furnace built by Surface Combustion Corp. which it will exhibit at its booth. These applications include case and homogeneous carburizing, carbon restoration, dry cyaniding, clean hardening, bright annealing, and hot oil quenching.

For the initial heating of hot blast stoves where gas may not be available for the first start-up, Hauck

Classified List of Exhibitors and Booth Numbers

Fuel-Fired Furnaces and Special Heating Equipment

American Gas Association—**2643, 2645, 2647, 2727, 2731, 2735, 2739, 2743, 2749, 2753, 2757**
American Gas Furnace Co.—**2749**
Cleveland Process Co.—**612**
Continental Industrial Engineers, Inc.—**2727**
Despatch Oven Co.—**2429**
Electric Furnace Co.—**242**
Gas Machinery Co.—**2757**
Granco, Inc.—**2767**
Harmon and Co.—**814**
Hauck Mfg. Co.—**2467**
Ipsen Industries, Inc.—**132**
Leeds & Northrup Co.—**2224**
North American Mfg. Co.—**1134**
Salem-Brosius, Inc.—**2454**
Selas Corp. of America—**2743**
Surface Combustion Corp.—**321**
Westinghouse Electric Corp.—**1611**

Electric Furnaces

Ajax Electric Co., Inc.—**221**
Continental Industrial Engineers, Inc.—**2727**
Despatch Oven Co.—**2429**
Electric Furnace Co.—**242**
Ferrotherm Co.—**432**
Heintz Mfg. Co.—**1001**
Ipsen Industries, Inc.—**132**
Leeds & Northrup Co.—**2224**
Lindberg Engineering Co.—**1521**
Salem-Brosius, Inc.—**2454**
Sentry Co.—**1103**
Upton Electric Furnace Co.—**2619**
Westinghouse Electric Corp.—**1611**

Induction Heaters

Allis-Chalmers Mfg. Co.—**2621**
Heintz Mfg. Co.—**1001**
Induction Heating Corp.—**930**
Lindberg Engineering Co.—**1521**
Ohio Crankshaft Co., Tocco Division—**2124**
Scientific Electric Division, "S" Corrugated Quenched Gap Co.—**2402**
Westinghouse Electric Corp.—**1611**

Atmosphere Preparation Equipment

American Gas Association—**2643, 2645, 2647, 2727, 2731, 2735, 2739, 2743, 2749, 2753, 2757**
Continental Industrial Engineers, Inc.—**2727**
Electric Furnace Co.—**242**
Heintz Mfg. Co.—**1001**
Ipsen Industries, Inc.—**132**
Leeds & Northrup Co.—**2224**
Lindberg Engineering Co.—**1521**
North American Mfg. Co.—**1134**
Salem-Brosius, Inc.—**2454**
Surface Combustion Corp.—**321**
Westinghouse Electric Corp.—**1611**

Quenching Equipment and Mediums

Ajax Electric Co., Inc.—**221**
Aldridge Industrial Oils, Inc.—**702**
American Cyanamid Co.—**2311**
Cities Service Oil Co.—**919**
Continental Industrial Engineers, Inc.—**2727**
Electric Furnace Co.—**242**
Gulf Oil Corp. and Gulf Refining Co.—**1140**
Houghton & Co., E. F.—**1019**
Ipsen Industries, Inc.—**132**
Leeds & Northrup Co.—**2224**
Park Chemical Co.—**314**
Salem-Brosius, Inc.—**2454**
Surface Combustion Corp.—**321**
Tide Water Associated Oil Co.—**2316**
Webber Mfg. Co., Inc.—**2766**

Supplies, Trays, Refractory Parts

Aldridge Industrial Oils, Inc.—**702**
Allied Chemical & Dye Corp., General Chemical Division—**2567**
American Brake Shoe Co.—**305**
Ashworth Bros., Inc., Metal Products Division—**2015**
Electro-Alloys Division, American Brake Shoe Co.—**305**
Fahralloy Co.—**2571**
General Alloys Co.—**251**
Nelson Stud Welding Division, Gregory Industries, Inc.—**2031**
Norton Company—**1933**
Ohio Steel Foundry Co.—**1116**
Park Chemical Co.—**314**
Rolock, Inc.—**2011**
Salem-Brosius, Inc.—**2454**
Sherman Electric Co., Inc.—**716**
Titanium Alloy Mfg. Div., National Lead Co.—**2409**

Vacuum Furnaces

Consolidated Vacuum Corp.—**1226**
National Research Corp.—**2007**

Industrial Ovens

American Gas Association—**2643, 2645, 2647, 2727, 2731, 2735, 2739, 2743, 2749, 2753, 2757**
Continental Industrial Engineers, Inc.—**2727**
Despatch Oven Co.—**2429**
Granco, Inc.—**2767**
Jensen Specialties, Inc.—**2139**
Lindberg Engineering Co.—**1521**
North American Mfg. Co.—**1134**
Westinghouse Electric Corp.—**1611**

Commercial Heat Treating Service

Induction Heating Corp.—**930**
Scott & Son, Inc., C. U.—**1015**

Heat Treating (Continued)

Mfg. Co. has developed a fuel-oil burner unit. Burners of this kind were first put into operation at the Moline Iron Works' malleable iron annealing furnaces. The flameless gas burners made by Granco Inc. and called "Irradiant Grid" will be shown at that company's booth. Premixed gases are delivered from any proportional mixer through a pressure chamber after being preheated in a retort to 600° F. The gas mixture burns within the ceramic grid and the burned gases travel through a series of flues to maintain a grid temperature of approximately 2200° F.

A radiant tube burner for controlled atmosphere furnaces will be one of the several kinds of burners which North American Mfg. Co. will exhibit. Designated as Series 122 "Evenglow", this burner is of the sealed-in type for use with 4-in. or larger radiant tubes. The tubes discharge the combustion products at the opposite end outside the furnace so that the furnace atmosphere is not contaminated. Air for the burner is supplied by a single pipe, but the supply is divided within the burner so that a part of it passes into the tube for mixing with the burning gas, thus prolonging combustion.

Temperature Indicators and Fuel Controls

Control of the many variables encountered in the operation of industrial furnaces continues to be reined into narrower limits and to become more complete, explicit and instantaneous. Indicators, recorders and controllers for temperature, pressure, fuel flow, furnace atmospheres, dew point and even chemical analysis, are being steadily refined to a level of uncanny accuracy, thanks mainly to the contributions of electronics.

Scanning the exhibits at the Show which accent the profit possibilities of better instrumentation, the visitor will be impressed by the trend toward specialization. As explained recently by John G. Garrett of General Electric Co.'s meter and instrument department: "With each new technical development in the world today, there is a corresponding increase in the demand for specialized electrical measuring devices . . . We expect demand for these devices nearly to double within the next decade. . . ."

Among the scores of indicators and recorders to be displayed by Leeds & Northrup Co. will be portable, panel, rack or cabinet designs, some of which provide as many as 126 temperatures or 16 mechanical load points to be checked in rapid succession. The instruments may be used with thermocouples, Thermohm or Rayotube detectors, as well as with load cells. Other portable and panel indicators have been developed to check steam or condensate purity, solution conductivity and hydrogen ion concentration. Even such out-of-the-ordinary factors as the ash content of raw sugar or the saltiness of soil come under the ready scrutiny of portable indicators.

Fast-acting electronic strip-chart recorders, such as those to be exhibited by Wheelco Instruments Division of Barber-Colman Co., partially explain the success the steel industry is having with immersion thermocouples of platinum and platinum plus rhodium, in observing temperatures of openhearth

Classified List of Exhibitors and Booth Numbers

Indicators and Recorders

Diamond Power Specialty Corp.—1630
Illinois Testing Laboratories, Inc.—1111
Leeds & Northrup Co.—2224
Pyrometer Instrument Co., Inc.—939
Sherman Electric Co., Inc.—716
Tempil® Corp.—841
West Instrument Corp.—2719
Wheelco Instruments Division, Barber-Colman Co.—2473

Pyrometers

Illinois Testing Laboratories, Inc.—1111
Leeds & Northrup Co.—2224
Pyrometer Instrument Co., Inc.—939
West Instrument Corp.—2719
Wheelco Instruments Division, Barber-Colman Co.—2473

Gas Samplers and Analyzers

Cities Service Oil Co.—919
Ipsen Industries, Inc.—132
Leeds & Northrup Co.—2224

Automatic Fluid and Pressure Controls

Leeds & Northrup Co.—2224
Maxitrol Co.—2647
North American Mfg. Co.—1134
Waukee Engineering Co.—1642

and electric furnace melts. A digest of progress in steelmaking temperature measurements, covering the experience of several plants with this type of couple, appeared in *Metal Progress* for June, p. 194.

Close checks on temperatures in lower ranges, such as in preheating for welding, tempering of toolsteels and in shell molding, can be expedited by crayon sticks, lacquers and pellets which become liquid at specified temperatures. Manufactured by Tempil Corp., these products for the first time will be available for temperatures of 413, 425, 438, 463, 475 and 488° F. Pellets also are made for the upper range of 2050 to 2500° F. Regulation of the dew point in controlled-atmosphere furnaces, essential to effective gas carburizing, carbo-nitriding, carbon restoration and other heat treatments, can now be accomplished with the aid of a self-contained unit which pumps furnace atmosphere through a 5/16-in. steel tube, and then condenses water vapor on a measuring element. Through an electronic hook-up, atmosphere dew point is directly indicated, recorded and controlled. This recorder was perfected by Ipsen Industries Inc.

Combustibles and oxygen content in furnace gases—measures of furnace combustion efficiency—are recorded on a direct-reading meter introduced several years ago to the industrial field by Cities Service Petroleum Inc. as an outgrowth of similar equipment used to analyze automotive and aircraft engine exhaust gases. The so-called "heat prover" for furnaces in the metals industries will be in action at the Show.

Welding and Associated Processes

Joining of metal components by welding and brazing is perhaps the most rapidly advancing science known to the hard-goods manufacturing industries today. Convincing proof will be found by inspection of the many exhibits at the Metal Show devoted to materials and equipment for welding operations in one form or another. Universally, the trend is to lessen dependence upon the skill of the individual operator and to build it into mechanical devices which, additionally, lower the burden of manual effort and insure uniformity of production.

Noteworthy are the many new installations of full automatic and semi-automatic "hidden-arc" welding throughout industry. In this system a supply of neutral flux is fed from a hopper or cone over the electrode wire and the arc, contributing to soundness and homogeneity of the weld deposit. Lincoln Electric Co. will have on display typical units for this work, including a semi-automatic "Squirt" welder which is manipulated by the operator but has automatic feed of the electrode wire. Fully automatic machines may be equipped with tandem heads or a twin-arc head where fast, straight-line operation is desired.

The latest Lincoln development is automatic hard facing with the flux-covered arc, using mild steel electrode wire and special agglomerated alloy-containing fluxes which may be varied in analysis to meet different service requirements. To speed up this machine hard facing, a new type of device has been developed to oscillate a standard welding head from side to side to deposit a wide bead.

For use in conventional hard facing by the manual method, a new alloy electrode, withstanding temperatures up to 1000 F. combined with light to medium impact and machinable as deposited, will be shown by American Manganese Steel Division of American Brake Shoe Co. It is considerably lower in price than cobalt-base alloys frequently used in this type of coating material.

Another concept of arc protection is a means of feeding a supply of neutral gas—argon or helium—around the bare electrode wire. Referred to by some as sigma welding (shielded inert-gas metallic-arc), it has created lively interest among metals engineers. Lincoln will show a new a-c. machine of this design, employing a modified method of preventing rectification of current and high-frequency interference with radar, television and radio communication, which is now mandatory under government regulations.

Viking Division of Progressive Welder Sales Co. also will exhibit a neatly packaged inert-arc welder, along with a standard direct-action spot welder and a d-c. rectifier arc welder.

Extrusion coated and spooled aluminum welding wire for use in the sigma process—somewhat of a rarity according to reports—will have top billing in the exhibit of Weldwire Co., Inc.

Resistance welding machines of the spot, seam and projection type have become standard production tools. Taylor-Winfield Corp. will show some of its designs which have been installed in aircraft and jet engine plants. They use d-c. current from a dry-disk rectifier system. This company also will feature its heavy-duty flash welders now at work in production of aircraft landing gear, rotary drill pipe and various ordnance items. In the past 7½ years,

Welding and Associated Processes (Continued)

Taylor-Winfield has installed the amazing total of 73,000 kva. of rated capacity in such flash welders and transformers.

Just how important are styling and color in something as prosaic as a welding machine? To judge for yourself, you can take a look at the new line of A. O. Smith Corp., completely restyled during the past year by a prominent industrial designer. Trim, smooth contours and striking color treatments will be apparent at once.

To meet exacting requirements in spot welding of aircraft components, Sciaky Bros., Inc., is demonstrating a novel bit of welding machine gadgetry—a "Micro-Metric" upper electrode holder with vernier adjusting knobs for longitudinal alignment of electrode tips (in and out) to a displacement of 1½ in. and radially to a total of 10° (5° right and 5° left of center).

Manual arc welding is always done preferably in the down-hand position, so most shops make use of positioners which allow the work to be moved to the proper angle for down-hand deposits. Steadily increasing size of weldments has meant a need for larger positioning equipment. Aronson Machine Co. will have one on display, capable of handling a 2000-lb. load and adjustable almost by finger touch.

Brazing of titanium alloys with the aid of special silver alloys has been the subject of recent intensive study by Handy & Harman. Preliminary work disclosed that the ever-present oxide film on the metal had to be dissolved first and the "denuded" titanium protected from further oxidation. Further, insulation was needed against absorption of nitrogen and hydrogen during brazing to avoid embrittlement. A flux containing acid fluorides solved the problem of oxidation, and a modified brazing technique with silver alloys produced butt joints in ½-in. and ¾-in. titanium rods with tensile strengths averaging 42,000 psi.—some as high as 52,000 psi. Samples will be available for inspection by Show visitors. The flux also is effective in brazing zirconium, tantalum and other refractory metals.

The new Aircraft Components Division of Ferrotherm Co. will have additional data to offer on brazing of titanium, using high temperatures and nickel-chromium brazing alloys. The system is already being used on gas turbine parts such as inlet guide vane assemblies, hollow-cooled turbine blading, variable area control nozzles, hot-section stator assemblies and a few other elements.

Cost-reducing methods used by a wide range of metalworking industries to overcome difficult joining problems will be featured by the Nelson Stud Welding Division of Gregory Industries, Inc., during the Metal Show. Nelson will also show a newly developed stud brazing technique in which its portable stud welding gun can be used for fastening studs to light-gage sheet metal.

Classified List of Exhibitors and Booth Numbers

Flame Welding and Cutting, Equipment and Supplies

American Brass Co.—141
Arcair Co.—710
Smith Welding Equipment—510
Union Carbide and Carbon Corp.—1508
Weldwire Co., Inc.—604

Arc Welding and Electrodes

Alloy Metal Wire Co., Inc.—2723
American Brass Co.—141
American Manganese Steel Division, American Brake Shoe Co.—305
Arcair Co.—710
Aronson Machine Co.—2435
Crucible Steel Co. of America—241
Empire Products, Inc., Cam-Lok Division—1634
Erico Products, Inc.—1011
Graham Mfg. Corp.—2572
Hobart Brothers Co.—2577
KSM Products, Inc.—2130
Lincoln Electric Co.—1712
Nelson Stud Welding Div., Gregory Industries, Inc.—2031
Rockwell Mfg. Co., Delta Power Tool Division—1310
Smith Corp., A. O.—231
Union Carbide & Carbon Corp.—1508
Weldwire Co., Inc.—604
Westinghouse Electric Corp.—1611

Resistance Welding

Alloy Metal Wire Co., Inc.—2723
Mallory & Co., Inc., P. R.—1626
Precision Welder & Flexopress Corp.—1924
Progressive Welder Sales Co.—2301
Rockwell Mfg. Co., Delta Power Tool Division—1310
Sciaky Bros., Inc.—2106
Scientific Electric Division, "S" Corrugated Quenched Gap Co.—2402
Taylor-Winfield Corp.—1907
Weltronic Co.—2312

Brazing and Soldering (Manual or Automatic)

Alpha Metals, Inc.—643
American Brass Co.—141
Electric Furnace Co.—242
Ferrotherm Co.—432
Handy & Harman—941
Lindberg Engineering Co.—1521
Nelson Stud Welding Division, Gregory Industries, Inc.—2031
Rockwell Mfg. Co., Delta Power Tool Division—1310
Scientific Electric Division, "S" Corrugated Quenched Gap Co.—2402
Union Carbide and Carbon Corp.—1508
Westinghouse Electric Corp.—1611

Fasteners

Acme Steel Products Division, Acme Steel Co.—2323
Eaton Mfg. Co., Reliance Division—515
Elastic Stop Nut Corp. of America—1120
Goodrich Co., B. F.—2417
Heli-Coil Corp.—2310
KSM Products, Inc.—2130
Nelson Stud Welding Div., Gregory Industries, Inc.—2031
Southco Division, South Chester Corp.—2769
Tinnerman Products, Inc.—1004

Positioners

Aronson Machine Co.—2435
Erico Products, Inc.—1011

Step up and try your own hand at welding steel studs to a backing plate in the exhibit of KSM Products, Inc., if you are so minded and need the exercise. Engineers will point out to you the features of a standard welding stud, including precisely controlled diameter and rolled threads, with carefully weighed and centered solid flux.

Rapid and economical gouging and cutting of all metals with the aid of a carbon arc electrode and holder hooked to a d-c. welding machine and a stream of compressed air directed just behind the arc will be demonstrated by Arcair Co.

In bolting to assemblies of aluminum, magnesium, brass, bronze, fiber, plastics or wood—where there is the danger of stripping tapped threads—thread inserts of stainless steel wire offer good insurance against damage. Heli-Coil Corp. will show 47 standard sizes of these inserts which it is now producing, for both original equipment manufacture and production salvage operations.

Synthetic resins are taking over as bonding materials, in place of welding and brazing, for many products. Eutectic Welding Alloys Corp. has some interesting data on resins bonds, showing how they stack up in comparison with welding, brazing and soldering. As a supplier of materials for making all four types of joints, the matter of bias should be minimized in this appraisal.



Fully Automatic Welding of Circumferential Seam in Exhaust Manifold for Natural-Gas Engine at Plant of Bos-Hatten Co., Buffalo. With this hidden-arc method flux is deposited from the hopper over the arc, while work revolves below. Standard Lincoln welding head is traversed on horizontal rail for longitudinal seams

Cleaning and Finishing

As ALWAYS, there is considerable activity in metal cleaning and finishing, and during the past year some of this was reflected in such novel developments as the descaling of hot worked steel by induction heating and the chemical polishing of iron. Certain trends, some of which began several years ago, are becoming more pronounced—as for example the use of ceramic coatings in alloys (lean in strategic metals) which are to be used at high temperatures. Also, the expanding applications for aluminum and magnesium are pushing the demand for better finishes and easier methods of applying them to these metals.

A trend which has definitely materialized during the past year is toward the use of ultrasonic frequencies for cleaning. In this process, electrical energy is transmitted to a transducer, converted into high-frequency sound energy and this is used to cause extreme turbulence in the cleaning solvent. Material to be cleaned is placed in the solvent (such as trichlorethylene) directly in the path of greatest focal intensity of the ultrasonic waves. Within this focal area, a penetrating cleaning action results that removes oil, grease, chips and other foreign matter almost instantaneously and from even the finest openings and crevices.

Exhibitors of this kind of equipment are Circo Equipment Co., Detrex Corp. and the Tocco Division of Ohio Crankshaft Co.; the latter two firms entered this field during the past year. The cleaning unit to be shown by Circo Equipment Co. employs a quartz crystal, while the Detrex "Sonicleau" unit employs barium titanate for the transducer. Energy from the former is beamed through an acoustic window located in the tank wall containing the alkaline or hydrocarbon cleaner; the transducer for the latter is immersed directly into the hydrocarbon solvent. Tocco plans to demonstrate the use of its new generator and related parts as applied to ultrasonic cleaning and degreasing. According to Tocco engineers, development of this generator makes possible the use of much greater amounts of ultrasonic power than has been practical up to this time. Ultrasonic cleaning is a big depar-

ture from induction heating, but the importance of this venture is indicated by the broad scope of the program under way at Tocco.

A vapor degreasing unit by Manufacturers Processing Co., identified as Model B-121, is said to have been engineered for "on the spot" cleaning so as to eliminate hauling and other handling of special degreaser baskets. Oakite Products, Inc., will explain how its new detergent, Composition No. 26, combines the cleaning action of alkaline and solvent-type cleaners and can speed the removal of tenacious heavy soils from iron and steel in a single immersion lasting from 1 to 10 min. Cold cleaning of metal parts will be featured by E. F. Houghton & Co. in its Houghto-Clean No. 439 and No. 440 for the removal of ordinary soils, drawing compounds, cutting oils and rust preventives. Pennsylvania Salt Mfg. Co. will exhibit a number of cleaning and deoxidizing agents for aluminum, as well as cleaning chemicals for iron and steel.

Some of the improvements in mechanical methods of cleaning which American Wheelabrator & Equipment Corp. has made recently will be explained at its booth. Among these is wet blasting and cleaning of nonferrous metals with "Liquasheen", a round abrasive grain that is propelled in a water slurry. It produces a more lustrous finish than that usually associated with wet blasting, and also has less tendency to "fingerprint" than do conventional wet-blasted surfaces. Attention will also be called to a liquid-type rust inhibitor using an organic material which goes into solution immediately and leaves no stains on rinsed work.

One of the latest additions to a varied line of polishing and buffing machines which Hammond Machinery Builders, Inc., will display is the Model 10 VBO variable speed polishing and buffing lathe. The machine, for floor mounting and of the overhanging-base type, is powered with a 10-hp. motor and has a speed range of 1500 to 3000 rpm. Diamond abrasive compounds for grinding, lapping and polishing will be exhibited by Engis Equipment Co.

A pesky problem in conveyer-line handling of articles for spray painting is the need to bring the items as close together as possible so as to present an essentially continuous surface for the coating operation, and the equally important need to change this grouping to normal spacing for transfer to subsequent operations. Ransburg Electro-Coating Corp. has provided the answer to this problem with its "grouping conveyer."

This equipment, a "package unit" adaptable to any standard overhead or spindle conveyer, controls transitions between normal and close spacings, and automatically transfers the items from and to the main conveyer. The grouping conveyer, in combination

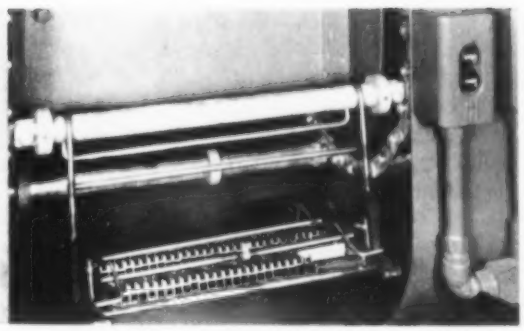


A New Thermal Insulating Material Called "Pyrolock" Protects Metal for as Long as 10 Sec. Against Flame Temperatures Hotter Than the Melting Point of the Metals. In this test, the untreated steel panel, at right, burned through in less than a second under an oxy-acetylene flame at approximately 5000° F. The steel panel treated with 1/16-in. coating, at left, was unharmed after 4½-sec. exposure to the flame. Pyrolock was developed by the B. F. Goodrich Co. at the request of the Defense Department for use in the rocket and guided missile field. Extensive laboratory tests have indicated that this insulating material resists higher temperatures for longer periods than any other preparation for similar use. It is resistant to most chemicals and solvents and has a high bonding strength

with the Ransburg "No. 2 Electro-Spray" process makes possible the automatic painting of square and rectangular articles about two and a half times faster than by hand spray.

Use of preplated metals for articles needing a protective or decorative finish offers favorable possibilities for many manufacturers wishing to avoid the cost and trouble of maintaining their own finishing departments. American Nickeloid Co. will exhibit strip and sheet steel, copper, brass, zinc and aluminum, one or both sides of which are electroplated with nickel, chromium, brass or copper. Also available are crimped, corrugated or striped sheets, electroplated with the metals mentioned in various degrees of reflectance. The metals are protected from damage during fabrication in the customers' shops by gummed paper, by plastic film (called "Mar-Not"), or by lacquer.

Industrial chromium plating units in sizes capable of plating from 10 to 500 sq.in. will be operated by the Ward Leonard Electric Co. Possible applications for these are the chromium plating of cutting tools, dies, gages and parts such as gears, cams, piston rings and shafts. A chromium solution called "Chromosol", for plating at room temperatures, is available for use in these units.



Removable Tray Used in the New Ultrasonic Degreaser Developed by Detrex Corp. for the Electric Shaver Division of Remington Rand, Inc. Each tray can hold 50 shaver heads

Chemical resistant equipment for electroplating, bonderizing, bright dipping, anodizing and pickling operations will be displayed by Heil Process Equipment Corp. Items shown will include acid tanks lined with Neoprene rubber, Koroseal, Saran and lead; fume exhaust hoods and duct sections of "Rigidon", a glass-reinforced polyester structural material; and acid-proof heating equipment constructed of "Nocordal", a form of impervious graphite.

Classified List of Exhibitors and Booth Numbers

Pickling, Cleaning, Degreasing

Allied Chemical & Dye Corp.—2567
Alvey-Ferguson Co.—2509
American Chemical Paint Co.—1104
American Cyanamid Co.—2311
American Wheelabrator & Equipment Corp.—2629
Blakeslee & Co., G. S.—929
Branson Instruments Co.—415
Circo Equipment Co.—2774
Cities Service Oil Co.—919
Cleveland Process Co.—612
Despatch Oven Co.—2429
Detrex Corp.—1807
Diversey Corp.—2008
Enthone, Inc.—2517
Heil Process Equipment Corp.—2415
Houghton & Co., E. F.—1019
Krouse Testing Machine, Inc.—1647
Manufacturers Processing Co.—2460
Oakite Products, Inc.—2573
Ohio Crankshaft Co., Tocco Division—2124
Osborn Mfg. Co.—1030
Park Chemical Co.—314
Parker Rust Proof Co.—2305
Pennsylvania Salt Mfg. Co.—1001
Rolock, Inc.—2011
Solventol Chemical Products, Inc.—730
Turco Products, Inc.—1406
Udylite Corp.—2529

Electroplating and Metallizing

Allied Chemical & Dye Corp., General Chemical Division—2567
American Manganese Steel Division, American Brake Shoe Co.—305
American Nickeloid Co.—2721
Circo Equipment Co.—427
Cleveland Process Co.—612
Consolidated Vacuum Corp.—1226
Enthone, Inc.—2517
Heil Process Equipment Corp.—2415
International Nickel Co., Inc.—332
National Research Corp.—2007
Pennsylvania Salt Mfg. Co.—1001
Tin Research Institute, Inc.—815
Udylite Corp.—2529
Ward Leonard Electric Co., Industrial Chrome Division—724

Grinding Wheels and Abrasive Belts

Curtis Machine Corp.—1211
DoAll Co.—1037
De Sanno & Sons, Inc., A. P.—2101
Engis Equipment Co.—142
Manhattan Rubber Division—2236
Norton Company—1933
Rockwell Mfg. Co., Delta Power Tool Division—1310
Udylite Corp.—2529

Rust Preventives and Paints

Aldridge Industrial Oils, Inc.—702
American Chemical Paint Co.—1104
American Wheelabrator & Equipment Corp.—2629
Goodrich Co., B. F.—2417
Heil Process Equipment Corp.—2415
Houghton & Co., E. F.—1019
Oakite Products, Inc.—2573
Parker Rust Proof Co.—2305
Pennsylvania Salt Mfg. Co.—1001
Ransburg Electro-Coating Corp.—1824
Shell Oil Co.—1944
Tide Water Associated Oil Co.—2316
Udylite Corp.—2529

Buffers and Polishers

Curtis Machine Corp.—1211
DoAll Co.—1037
Engis Equipment Co.—142
Hammond Machinery Builders, Inc.—1150
Lee Co., K. O.—2441
Martindale Electric Co.—2616
Murray-Way Corp.—715
Nicholas Equipment Co.—2324
Osborn Mfg. Co.—1030
Production Machine Co.—1709
Rockwell Mfg. Co., Delta Power Tool Division—1310
Udylite Corp.—2529

Equipment for Purification of Solutions

Circo Equipment Co.—2774
Commercial Filters Corp.—2665
Krouse Testing Machine, Inc.—1647
Murray-Way Corp.—715
Sparkler Mfg. Co.—1638
Udylite Corp.—2529

Testing and Inspection Equipment

TO KEEP ATTUNED to the tempo of today's production and to insure unfailing adherence to quality standards, equipment and devices for testing and inspection of metals are moving from the laboratory out onto the production line. There they must meet requirements for fast action and ruggedness not always too essential in the more leisurely pace of the laboratory.

Nondestructive testing assumes new importance in the light of the foregoing, so we see X-ray machines fitted to conveyer lines to check soundness of castings and fabricated parts as fast as they move by, and adaptations of fluoroscopy to the X-ray to dispense with the delay incident to development and viewing of film.

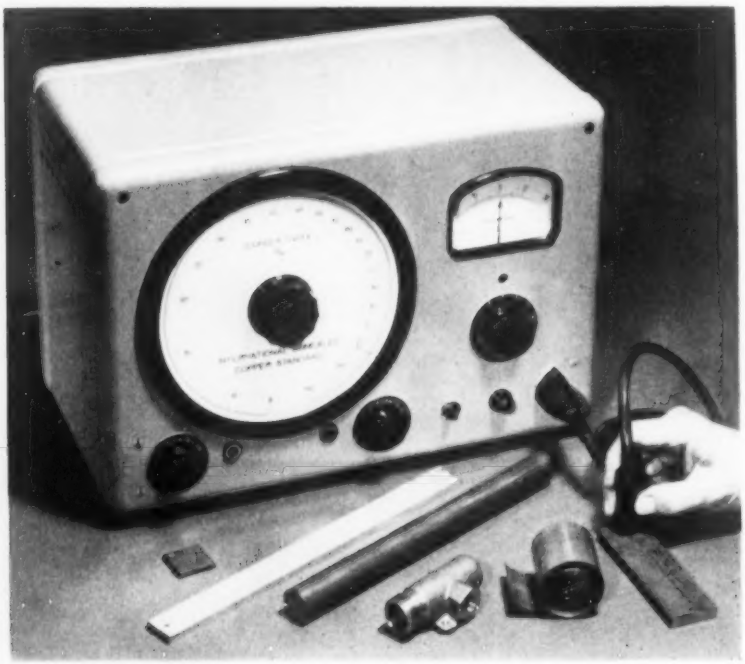
Westinghouse Electric Corp. will show how conveyerized X-ray inspection works with its Productograph unit, and will also demonstrate the X-ray fluoroscope. The theme of the entire Westinghouse display will be "automation in the modern plant" and each piece of equipment to be shown in the booth has been evaluated on the basis of its relation to in-line production.

Portable X-ray machines, operating on 110-220-440 v. and in capacities of 120, 175 and 250 kva., have been used in Denmark for metals inspection over the past six years. Holger Andreason, Inc. now has them for U.S. manufacturers. No high-tension cables, cooling pumps and connections, or separate transformers are necessary.

X-ray diffraction equipment, including a wide-range goniometer, wide-range diffractometer, 90° diffractometer and an X-ray spectrograph for rapid qualitative and quantitative analysis, shown by North American Philips Co., Inc., may give production control experts some new ideas.

Direct-reading spectrometers, while involving considerably more than peanuts in the way of capital expenditure, are being put to profitable use by many companies. *Metal Progress* for September told how Fairchild Aircraft makes use of a unit for production inspection offered by Baird Associates, Inc. Several electric furnace steel plants also use the machines for split-second chemical analyses, covering as many as 12 elements at a time. Baird will greet Show visitors with a new comparator densitometer for emission spectroscopy, an automatic servo-type instrument calibrated to read photographic densities directly on a linear scale.

Conductivity of Nonferrous Metals Is Read Directly on the Dial of This New Meter Introduced by Magnaflux Corp. All that is needed is a ¾-in. diameter flat area on the sample to accommodate the probe



A "spectacular spectrograph" is about all Jarrell-Ash Co. will say at the moment about the device which it will give top billing. Precision and automaticity are said to outdistance even the company's present spectrographic equipment.

For spotting internal flaws in metals, ultrasonic testing equipment is proving a trustworthy detective. The Reflectoscope built by Sperry Products, Inc. is one type of internal searcher which can be beamed across diameters, anglewise or endwise to locate discontinuities "on the job". Penetrating up to 30 ft. of material, it has been used to advantage on such parts as gear blanks, casing and tubing couplings, forging press columns, die blocks, rolls and cold drawn shapes.

A variety of ultrasonic equipment will be displayed by Branson Instruments Inc., one of the

latest being an ultrasonic transmission unit for production testing of uniform parts. Comprising ultrasonic generator, transmitter and receiver, it indicates defects by a change of ultrasonic transmission through parts placed in a liquid bath. Branson also will take the wraps off a 400-watt ultrasonic generator, with focused transducer, designed primarily for degreasing and cleaning small parts.

Hardness testers, too, are moving onto the production line. Steel City Testing Machines, Inc. will unveil a Brinell tester with a fixed anvil incorporating rollers which become a part of the conveyer system. Once the part is located on the anvil under the penetrator, the rollers depress, then raise again after the test cycle.

Portable Brinell testers which can probe into grooves and other restricted areas on all sizes and types of parts anywhere along the processing sequence are to be exhibited by Andrew King. Similar pocket-size testers for both Brinell and Rockwell hardness can be seen at the Newage International Inc. booth.

Motorized hardness testing machines, for either standard or superficial Rockwell checks, will be shown for the first time by Service Diamond Tool Co. They are designed for complete shutoff of motorized elements during the actual penetration cycle, eliminating a frequent source of error.

The job of the metallographer becomes progressively less tedious and tiring as suppliers improve and refine the equipment he uses. Simple devices like Bausch & Lomb Optical Co.'s Magna-Viewer for

Classified List of Exhibitors and Booth Numbers

Strength-Testing Equipment

American Machine and Metals, Inc., Riehle Testing Machines Division—1129
Baldwin-Lima-Hamilton Corp.—1139
Buehler Ltd.—115
Detroit Testing Machine Co.—1216
Krouse Testing Machine, Inc.—1647
Olsen Testing Machine Co., Tinius—1812
Opplem Co., Inc.—160
Steel City Testing Machines, Inc.—830

Hardness Testers

American Chain & Cable Co., Inc., Andrew C. Campbell Division—1716
American Machine and Metals, Inc., Riehle Testing Machines Div.—1129
Baldwin-Lima-Hamilton Corp.—1139
Buehler Ltd.—115
Detroit Testing Machine Co.—1216
Ercona Corp.—602
Harshaw Scientific Division of Harshaw Chemical Co.—1734
King, Andrew—408
Leitz, Inc., E.—801
Newage International, Inc.—411
Olsen Testing Machine Co., Tinius—1812
Opplem, Co., Inc.—160
Service Diamond Tool Co.—721
Steel City Testing Machines, Inc.—830

Microscopes and Attachments

American Optical Co., Instrument Division—1829
Bausch & Lomb Optical Co.—322
Buehler Ltd.—115
DoAll Co.—1037
Ercona Corp.—602
Harshaw Scientific Division of Harshaw Chemical Co.—1734
Jarrell-Ash Co.—1427
King, Andrew—408
Leitz, Inc., E.—801
North American Philips Co., Inc.—1740
Opplem Co., Inc.—160
Scherr Co., Inc., George—626

Analytical Equipment and Supplies

Applied Research Laboratories—308
Baird Associates—2012
Bausch & Lomb Optical Co.—322
Harshaw Scientific Division of Harshaw Chemical Co.—1734
Jarrell-Ash Co.—1427
Laboratory Equipment Corp.—2653
Leitz, Inc., E.—801
Lindberg Engineering Co.—1521
National Spectrographic Sales Corp.—402
North American Philips Co., Inc.—1740
Opplem Co., Inc.—160

Radiographic Equipment, Other Nondestructive Testing

American Cystoscope Makers, Inc.—1730
Applied Research Laboratories—308
Branson Instruments, Inc.—415
Brush Electronics Co.—1220
General Electric Co., X-Ray Dept.—1328
Harmon and Co.—814
Harshaw Scientific Division of Harshaw Chemical Co.—1734
Holger Andreasen, Inc.—803
Magnaflux Corp.—1833
North American Philips Co., Inc.—1740
Sperry Products, Inc.—1010
Tracerlab, Inc.—2677
Turco Products, Inc.—1406
Westinghouse Electric Corp.—1611

Gages, Comparators and Associated Devices

American Machine and Metals, Inc., Riehle Testing Machines Division—1129
Baldwin-Lima-Hamilton Corp.—1139
Branson Instruments, Inc.—415
Brush Electronics Co.—1220
Collins Microflat Co.—2666
DoAll Co.—1037
Engis Equipment Co.—142
Ercona Corp.—602
Krouse Testing Machine, Inc.—1647
Micrometrical Mfg. Co.—1635
Scherr Co., Inc., George—626
Starrett Co., L. S.—2603
Tubular Micrometer Co.—1621

Electronic Test Accessories

Baldwin-Lima-Hamilton Corp.—1139
Brush Electronics Co.—1220
Continental Tooling Service, Inc.—1729
DoAll Co.—1037
Magnaflux Corp.—1833
Sperry Products, Inc.—1010
Weltronic Co.—2312

Scientific Equipment

American Machine and Metals, Inc., Riehle Testing Machines Division—1129
American Optical Co., Instrument Division—1829
Applied Research Laboratories—308
Bausch & Lomb Optical Co.—322
Branson Instruments, Inc.—415
Buehler Ltd.—115
Ercona Corp.—602
Harshaw Scientific Division of Harshaw Chemical Co.—1734
Illinois Testing Laboratories, Inc.—1111
Industrial Tectonics, Inc.—1645
Laboratory Equipment Corp.—2653
Leitz, Inc., E.—801
National Diamond Laboratory—2752
National Spectrographic Sales Corp.—402
North American Philips Co., Inc.—1740
Opplem Co., Inc.—160
South Florida Test Service—405
Tinchet Products Co.—2552

Testing and Inspection Equipment (Continued)

attachment to metallographs to bring enlarged images directly in line with the operator's vision, or American Optical Co.'s desk-type metallograph, having all controls within easy reach of a seated operator, are cases in point. As A. B. Kinzel stated in his summary of latter-day metallography (*Metal Progress* for January 1953), we have "come a long way since the early difficult years when Albert Sauveur brought metallography to a high state of art . . . Advances will go on . . . the gap between the crystal and the atom will be ever narrowed."

One of the old standbys in physical testing equipment which indeed has "come a long way" is the universal testing machine, now built in both hydraulic and screw-power types by Riehle Testing Machines Division of American Machine & Metals, Inc. Hydraulic models may be preferred in production tensile testing by virtue of their speed and relatively simple construction detail; screw types can hold a stress in the elastic range indefinitely when loading is stopped and can handle greater off-center loads than hydraulics.

Specialized inspection and testing mechanisms and systems are virtually limitless, as the Metal Show will prove, running the gamut from clever laboratory aids like an automatic, electronically controlled titrator for sulphur exhibited by Laboratory Equipment Corp. to more complex tools such as Magnaflux Corp.'s new conductivity meter, both shown for the first time. The latter gives absolute conductivity measurements of nonferrous metals on a large dial at the front, an operator merely placing the ¾-in. diameter probe on the part to be tested and reading the dial.

A surface resistance indicator for testing coupons of aluminum and other material of low surface resistance, as a criterion for successful welding, will be operated by Weltronic Co. Surface resistance down to one millionth of an ohm can be noted on a direct-reading scale.

To "feel" the surface of normally inaccessible areas by means of the Profilometer, two new tracer points have been developed by Micrometrical Mfg. Co. One will reach the bottoms of small grooves and over shoulders; the other is designed for internal tapers and shoulders usually requiring the use of a dogleg beam.

Another surface feeler, originating in the Research Laboratories Division of General Motors Corp., is sensitive to variations on the order of one micro-inch and still is rugged enough for production line use. Brush Electronics Division of Clevite Corp. will tell you how it works.

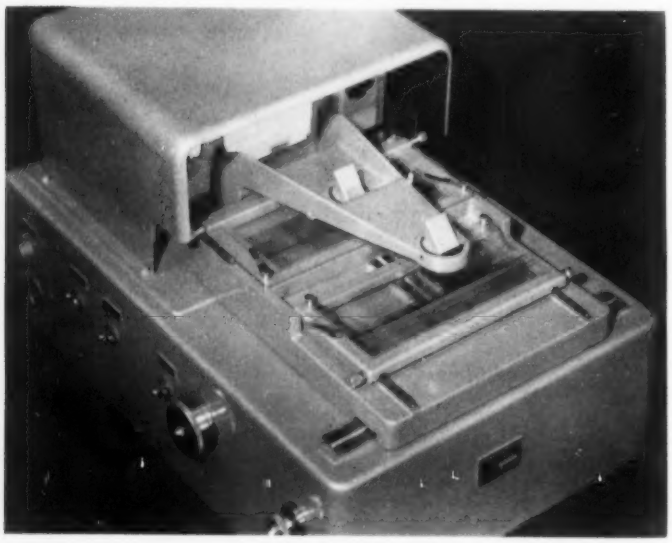
If the problem is to "see" internal surfaces – say the inside of a butt welded high-pressure pipe – American Cystoscope Makers, Inc. offers its borescope which can be flexed at a 90° angle when inserted in a test hole several inches from the weld.

To determine the possibility of shorts between segments or defective dielectrics in commutators of subminiature and fractional-horsepower motors, ConRay Corp. (subsidiary of Continental Tooling Service, Inc.) will operate a small tester handling 90 to 200 pieces per hr.

Thickness of electroplating, enamels and paints frequently must be checked as a quality control procedure. Instruments have been perfected to do the job quickly and nondestructively. Krouse Testing Machine Co., for example, will show how it is done with a magnifying micrometer which measures the force necessary to overcome magnetic attraction between its precision formed permanent magnet and the magnetic base material.

Testing porosity in pressure castings is expedited by Tinchet Products Co.'s new Leak-O-Meter, a fast and economical instrument.

Comparator Densitometer for Emission Spectroscopy Is a New Product of Baird Associates, Inc. It is a double-beam, automatic, servo-type instrument calibrated to read photographic densities directly on a linear scale



Industrial Equipment

MECHANICAL power is furnishing the brawn for a full complement of handling operations in progressive metalworking plants, all the way from raw material to inter-machine transfer and on to finished product. Even the removal of scrap from machines has become conveyerized to avoid costly shutdowns and to minimize the requirement for manual labor in waste disposal. In addition to conveyers and other materials handling equipment, both stationary and mobile, there are scores of what might be termed plant auxiliaries, all aimed at speeding up production processes, trimming costs, overcoming the fallibilities of the human element and making jobs safer and more pleasant.

Automatic removal of chips and turnings from high-speed automatics and multiple-spindle machines by inclined power conveyer can increase machine output by as much as 20%, according to May-Fran Engineering, Inc. The illustration below shows a special conveyer unit developed for this task. Belt is of hinged steel links, assembled into any desired width and carrying overlapping wings on the ends. Drive is through motor and speed reducer. Chips from the machine fall on the belting at its lower end, are carried up a 60° incline and are spilled into a tote box or collecting conveyer. Coolant drains off the scrap through perforations in the belt links.

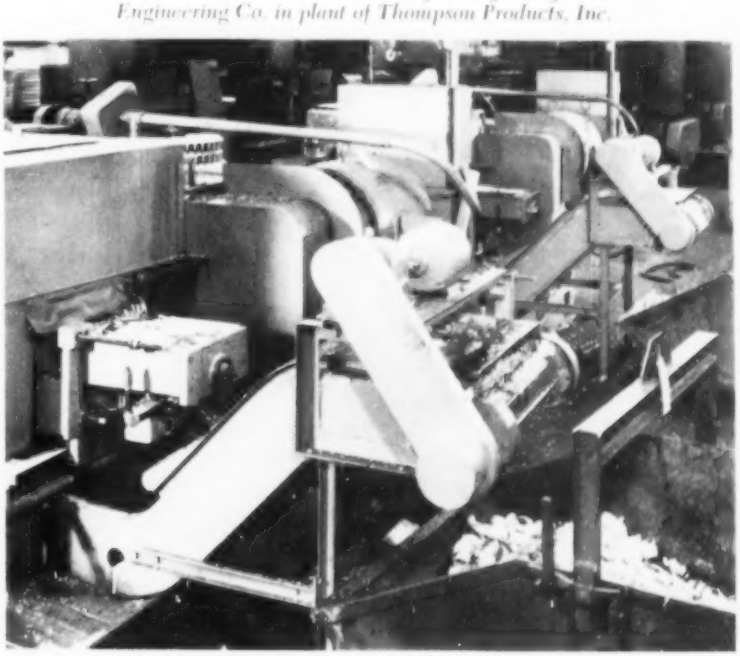
Variations of the so-called Chip-Tote can be arranged to pick up small forgings or stampings; in a portable design, it can be positioned to transfer parts from one stamping press to the next. The hinged steel belt is suited to plant-wide collection systems. A toy manufacturer, for example, has installed more than 1½ miles of it to bring scrap from a long line of presses to a baler. Still another version utilizes the belts as feeder-conveyers to deliver small forgings, castings, stampings and machined parts to heat treating furnaces, sandblast machines, washers or other processing.

Portable inclined power conveyers for light-duty parts or scrap handling in pressrooms or machine shops also will be shown by Rapids-Standard Co., Inc. Belts are of cleated fabric for quiet operation. This exhibitor will co-feature a brand new heavy-duty gravity roller conveyer, made in 15 to 51-in. widths and 5 to 10-ft. lengths, and beefed up for particularly heavy and bulky loads.

Air power is being put to work in a wide assortment of machine mechanisms. Mead Specialties Co., for instance, has perfected pneumatic devices for work holding, work feeding, chip blowing and parts ejection that contribute importantly to high-speed repetitive operations on small parts. Likewise, A. Schrader's Son will show how compressed air can be harnessed to eliminate lost motion, increase output and enhance safety. Pneumatic cylinders, valves, controls, blow guns, couplers, ejection sets and trips for power presses are among the machine aids to be displayed.

Automatic feeding of thin steel sheets or laminations into forming presses has long been a goal of the "automation" experts and thus far it has defied their best efforts. Basco Mfg. Co. may have a solution in its sheet separator which has a permanent magnet to induce a magnetic field in stacked sheets, causing the ends to repel each other and fan out

Inclined Power Conveyers With Belts of Hinged Steel Links Pull Turnings as They Fall From Tools of These High-Speed Automatic Lathes, Depositing Them in Tote Boxes. Conveyers by May-Fran Engineering Co. in plant of Thompson Products, Inc.

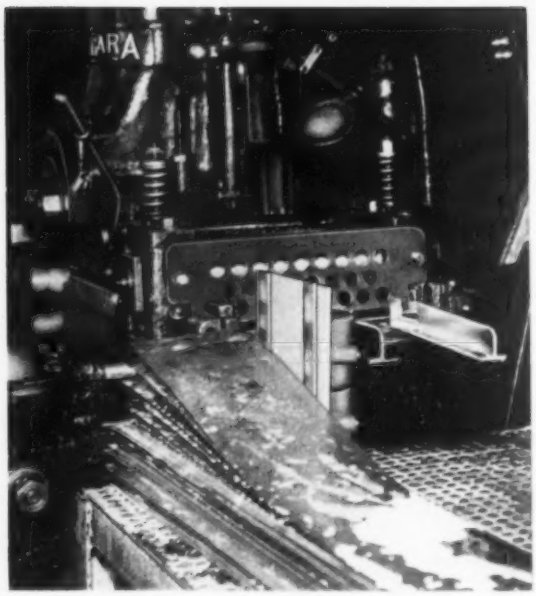


with air space between them, no matter what coating material may be present on the steel. Once separated, the sheets are easily moved into press roll feeds.

Wired television as an aid to materials handling, as a watchdog over combustion processes and as a sort of centralized "plant intelligence" may be still in its infancy, but appears to have many worthwhile potentialities. Diamond Power Specialty Corp. will operate its Utiliscope television equipment for Show visitors and will explain how it is presently being used in industry.

For the innumerable odd jobs of handling materials and equipment up to 15,000 lb., Coles Cranes, Inc. has designed a novel full-circle slewing mobile crane. It is rubber-tired and gas-electric powered, thus having no clutches to wear out. A single operator works from an enclosed cab and has full control over individual motors powering the hoist, derrick, slew and travel motions. It is hoped to have the crane moving about the exhibit area.

A quick look at other Show-stoppers in the generalized field of industrial equipment includes: tube fittings, requiring no threading, welding, soldering or special tools for installation—Weatherhead Co. . . . desk-side copying machine for making black-on-white diazotype copies of work sheets up to 20 in. wide—Charles Bruning Co., Inc. . . . dial-actuated electric dispenser which spews out measured lengths of glued paper packaging tape, moistened and ready for sticking, at a rate of 3 ft. per sec.—Marsh Stencil Machine Co. . . . identification badge camera which snaps an employee's photo, number and other data, and prints the badge, all in a mere 90 sec.—Anderson & Sons, Inc. . . . completely new airfoil centrifugal fans for heating, ventilating and air conditioning—Chicago Blower Corp. . . . air-actuated clutches and brakes with single moving members—an inflatable, circumferential "inner tube"—Fawick Airflex Co., Inc. . . . an improved bench-type undercutter for commutator maintenance—Martindale Electric Co.



Basco's Automatic Magnetic Separator for Steel Sheets Induces a Magnetic Field Which Causes the Sheets to Repel Each Other and Fan Out With Air Spaces Between

Your "show of shows" in the metals industries, as the foregoing pages suggest, will ably reflect progress in materials, processes and equipment which daily are reinforcing the might of industrial America. The products, materials and equipment described in the foregoing pages are only a sampling of what to expect at the Metal Show at the Cleveland Public Auditorium, Oct. 19 through 23. Many other developments equally important to the metals engineer will be on display, and qualified representatives of the manufacturing companies will be on hand to furnish detailed information.

Classified List of Exhibitors and Booth Numbers

Materials Handling

Acme Steel Co., Acme Steel Products Division—2323
Ashworth Brothers, Inc.—2015
Baldwin-Lima-Hamilton Corp.—1139
Basco Mfg. Co.—2338
Coles Cranes, Inc.—2674
Diamond Power Specialty Corp.—1630
Fenway Machine Sales Co., Inc.—423
Gray Co., Inc.—2470
Invincible Vacuum Cleaner Mfg. Co.—2703
Marsh Stencil Machine Co.—2618
May-Fran Engineering Co.—1911
Merrill Brothers—625
Rapids-Standard Co., Inc.—718
Rolock, Inc.—2011
Salem-Brosius, Inc.—2454
Sparkler Mfg. Co.—1638

Miscellaneous Mill Supplies and Equipment

Adjusto Equipment Co.—2471
Allis-Chalmers Mfg. Co.—2621
American Wheelabrator & Equipment Corp.—2629
Anderson & Sons, Inc.—260
Bruning Co., Charles—2016
Chicago Blower Corp.—615
DoAll Co.—1037
Fawick Airflex Co., Inc.—2421
Fenway Machine Sales Co., Inc.—423
Flexonics Corp.—616
Lee Co., K. O.—2441
Lewis Machine Co.—819
Martindale Electric Co.—2616
Master Builders Co.—2754
Mead Specialties Co., Inc.—403
National Diamond Laboratory—2752
Schrader's Son Division, A., Scovill Mfg. Co., Inc.—2112
Sly Mfg. Co., W. W.—2560
Torit Mfg. Co.—1641
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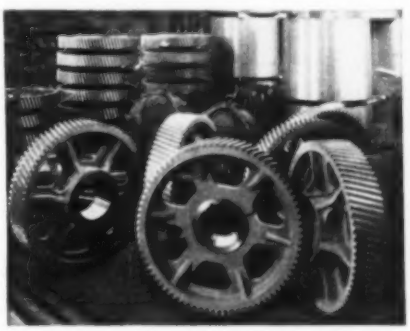
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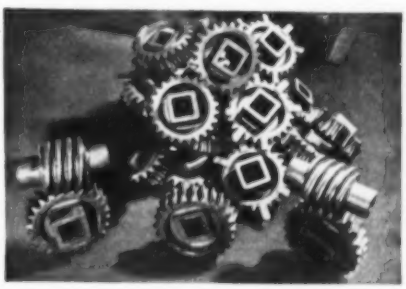
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Small Gears ... also worms ... exemplify an application of Ductile Iron in the railroad field.

THE INTERNATIONAL NICKEL COMPANY, INC.

67 WALL STREET
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Specifications for Copper and Copper Alloy Welding Rods

Compiled from "Tentative Specifications for Copper and Copper Alloy Welding Rods", A.S.T.M. designation B259-52T and A.W.S. A5.7-52T. Data prepared by the A.W.S.-A.S.T.M. Joint Committee on Filler Metal.

Chemical Requirements

Common Name	Type, A.W.S.-A.S.T.M. Classification	Composition, %										
		Copper	Zinc	Tin	Manganese	Iron	Silicon	Nickel	Phosphorus	Aluminum	Lead	Total Others*
Copper	R Cu	98.0†	N S‡	1.0	0.5	*	0.50	*	0.15	0.01*	0.05*	0.50
Copper-silicon (Silicon bronze)	R Cu Si-A	94.0†	1.5[a]	1.5[a]	1.5[a]	0.5	2.8 -4.0	*	*	0.01*	0.05*	0.50
	R Cu Si-B	97.0†	1.5[a]	1.5[a]	1.5[a]	0.5	1.0 -2.0	*	*	0.01*	0.05*	0.50
Copper-tin (Phosphor bronze)	R Cu Sn	94.0†	*	4.0-6.0	*	*	*	*	0.20-0.30	0.01*	0.05*	0.50
Copper-nickel	R Cu Ni	67.0	1.0	1.2	1.25	0.60	0.10-0.50	29.0-33.0	0.0	N S	0.01*	0.50
Copper-zinc												
Naval brass	R Cu Zn-A[b]	57.0†	R§	0.25-1.0	*	*	*	N S	N S	0.01*	0.05*	0.50
Manganese bronze	R Cu Zn-B	56.0†	R	0.5 -1.0	0.01-0.50	0.25-1.00	N S	0.50	*	0.01*	0.05*	0.50
Low-fuming bronze	R Cu Zn-C	56.0†	R	0.75-1.1	0.01-0.50	0.25-1.25	0.04-0.25	1.00	N S	0.01*	0.05*	0.50
Nickel bronze	R Cu Zn-D	45.0†	R	N S	N S	N S	0.04-0.25	9.0-11.0	0.25	0.01*	0.05*	0.50
Aluminum bronze	R Cu Al-A1	R	0.02	N S	N S	N S	0.10	N S	N S	6.0- 9.0	0.02	0.50
	R Cu Al-A2	R	0.02	N S	N S	1.5	0.10	N S	N S	9.0-11.0	0.02	0.50
	R Cu Al-B	R	0.02	N S	N S	3.0 -4.25	0.10	N S	N S	11.0-12.0	0.02	0.50

Mechanical Requirements

Type	Tensile Strength, % Minimum		Applicable Processes[c]	Standard Diameters, In.[e]	Preheat and Interpass Temperatures, °F.	
	Copper Alloy Base Plate	Steel Base Plate			Minimum	Maximum
R Cu	25,000	—	C, O, I	1/16, 3/32, 1/8, 5/32, 3/16, 1/4	600	1000
R Cu Si-A	50,000	—	C, O, I	1/16, 3/32, 1/8, 5/32, 3/16, 1/4	60	220
R Cu Si-B	35,000	—	C, O	1/16, 3/32, 1/8, 5/32, 3/16, 1/4	60	220
R Cu Sn	35,000	—	C, I	1/8, 5/32, 3/16, 1/4	350	550
R Cu Ni	50,000	—	O	1/16, 3/32, 1/8, 5/32, 3/16, 1/4	60	220
R Cu Zn-A	50,000	40,000	O	1/16, 3/32, 1/8, 5/32, 3/16, 1/4	350	550
R Cu Zn-B	55,000	45,000	O	1/16, 3/32, 1/8, 5/32, 3/16, 1/4	350	550
R Cu Zn-C	57,000	50,000	O	1/16, 3/32, 1/8, 5/32, 3/16, 1/4	350	550
R Cu Zn-D	—	60,000	O	1/16, 3/32, 1/8, 5/32, 3/16, 1/4	350	550
R Cu Al-A1	55,000	—	C[d], I	3/32, 1/8, 5/32, 3/16, 1/4	300	400
R Cu Al-A2	65,000	—	C[d], I	3/32, 1/8, 5/32, 3/16, 1/4	300	400
R Cu Al-B	70,000	—	C[d], I	1/8, 5/32, 3/16, 1/4	300	400

Notes

*Total other elements, including those marked (*), shall not exceed the value specified.

†Minimum, including silver for R Cu.

‡Not specified.

§Remainder.

[a]One or more of these elements may be present within the limits specified.

[b]B Cu Zn-2 brazing filler metal (A.S.T.M. designation B 260) also meets these requirements; the two may be used interchangeably.

[c]C = carbon-arc welding; O = oxy-acetylene welding; I = inert-gas arc welding (nonconsumable electrode). Electrodes used with the inert-gas (consumable electrode) process are covered by separate specifications A.S.T.M. designation B 225.

[d]Rods shall be coated for carbon-arc welding.

[e]Permissible variation on drawn rods, 5/32 in. and under, ±0.003 in.; 3/16 in. and over, ±0.004 in. On swaged rods, 5/32 in. and under, ±0.01 in.; 3/16 in. and over, ±0.02 in. Standard packages shall be of 25, 50 and 100 lb. net weight.

The specifications also prescribe mechanical tests to demonstrate properties, soundness and ductility of the deposited metal. These include a transverse tension test for mechanical properties and a guided-bend test for soundness and ductility of the weld metal.

An appendix covering selection of rods includes such factors as flame adjustment, type of current, preheat, backing, flux, edge preparation and position of welding.

How IBM saves heat treating dollars using AEROCARB® E&W Carburizing Compounds on Executive Model electric typewriter parts

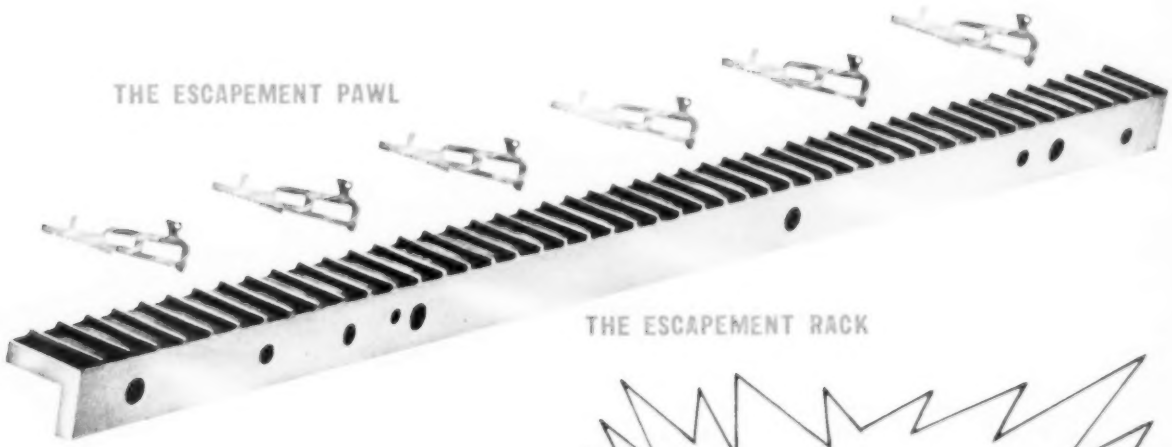
Here are two examples typical of the way International Business Machines Corp. saves money at its Endicott and Poughkeepsie plants by using Aerocarb E&W.



Treatment: Made of AISI 1035 steel, the pawl is carburized in AEROCARB E&W for about a half hour at 1550°F to a case depth of .006–.008", then oil quenched and tempered to a hardness of Rockwell 52-55 C.

Advantages: Desired wear resistance and impact resistance obtained. An extremely important factor is minimum distortion – pawls are held flat within .002", and parallel within .001". Parts are also easily washed.

THE ESCAPEMENT PAWL



THE ESCAPEMENT RACK

Treatment: Made of AISI 4615 steel, the rack is carburized in AEROCARB E&W at 1650°F for one hour to produce a case depth of .015–.017". It is then air cooled and the solidified salt removed by a hot water rinse. Next, the teeth *only* of the rack are hardened by *high frequency induction* heating followed by a water quench. Tempering completes treatment and teeth must meet a Rockwell hardness specification of 80-82 A.

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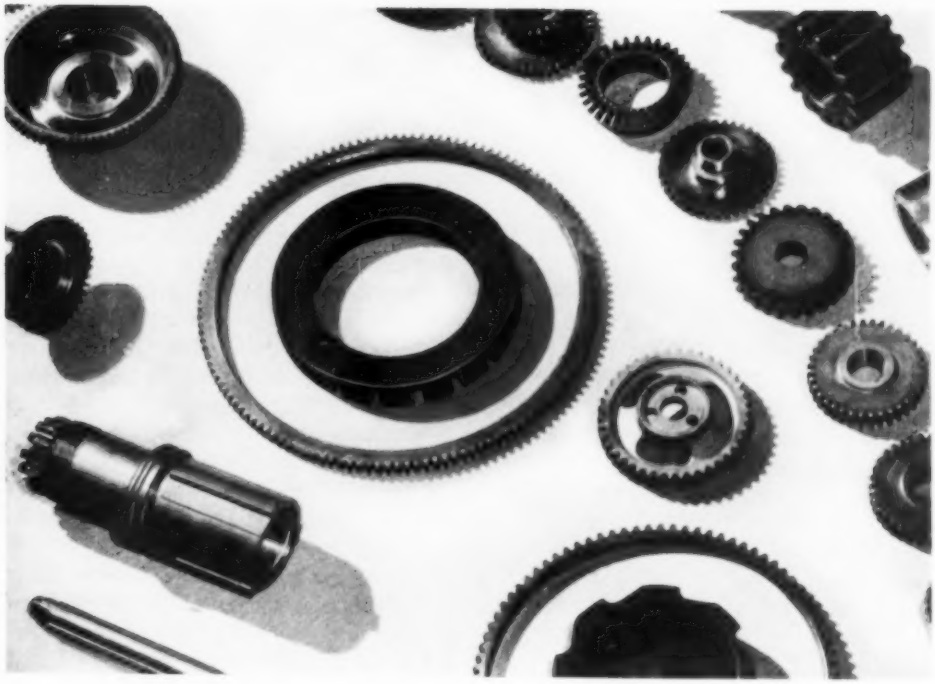
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Flame Hardening Machines Speed Treatment of Engine Components

SELECTIVE surface hardening of iron and steel parts by the high-temperature gas flame, followed by immediate quenching, is a fairly common practice in the field of heat treatment and one which has been undergoing steady refinement in terms of precise control, automaticity and speed. Mechanization of flame hardening has seen the development of what might be termed "heat treating machines" with all the flexibility, compactness and positive control of the modern lathe or milling machine. They mark a distinct forward advance in the science of heat treating and provide a valuable tool for high-production plants in the automotive field.

In laying out the facilities for production of the Buick V-8 engine, it was decided on the basis of extensive tests to adapt flame hardening equipment of advanced design to the localized treatment of wear areas on camshafts, pushrods, rocker arms, rocker-arm shafts and starter ring gears. Previously, all were hardened by other methods. Speed, ease of equipment maintenance, relatively low fuel cost, minimum space requirements and fully automatic features were among factors leading to the adoption of flame hardening. Another important factor was that the equipment could be incorporated directly in the production line, making for orderly flow of parts through the manufacturing steps, as well as reduced handling expense.

In all, ten machines have been installed—three for rocker arms, two each for camshafts, rocker-arm shafts and pushrods, and one for

By ARTHUR H. ALLEN
Technical-Business Consultant
Cleveland

Fuel Gas for Flame Hardening

ring gears. They are of similar basic design, comprising the hardening unit itself, flanked by a separate control cabinet to accommodate gas control and regulator devices. They are Cincinnati Milling Machine Co. Flamatic machines, in the design of which Buick engineers participated importantly. Noteworthy is their high degree of adaptability, in that positioning of burners and fixtures may be changed readily to handle parts of the same shape but perhaps of slightly different size.

Fuel gas is a mixture of oxygen and propane in the ratio of 3.5 to 1. Since a constant flow of gas is a requisite for efficient flame hardening, special precautions are taken to assure that exact regulation of pressures and metering of supply will be continuous.

Both oxygen and propane are brought to the machine regulator cabinets by overhead lines from a storage located some distance from the plant building. Propane is stored in a 35,000-gal. tank, oxygen in large bottles mounted on a truck-trailer. Plant pipelines, suspended from roof trusses, are equipped with valves which close in event of a pressure drop of 3 lb., this being just one of many safety precautions of the entire installation.

Pressure in the oxygen line is 120 lb. In the regulator cabinet this is first reduced to 80 lb. and then to 74 lb. ahead of a metering orifice from which it emerges at 10 lb. (for the push-rod machines). Pressures will vary slightly for different parts, depending upon the arrangement of burners and number of ports in them, the aim being to effect a gas flow from the burners of 400 to 450 ft. per sec.

Propane is delivered at a line pressure of 35 lb., this being regulated down to 3.5 lb. (on pushrods; higher on other parts—up to 14 lb.) after first passing through a stabilizing regulator outside the control cabinet. Before flowing to a mixing manifold, the propane is fed across a hydraulic back-pressure valve to insure against backflash. Gas lines are all-welded steel pipe, with silver soldering being used at regulator joints on the high-pressure side and soft soldering on the low-pressure side. Propane, oxygen, water and air lines are painted with identifying colors and the propane lines are labeled at intervals.

Oxygen and propane are mixed in a manifold at the rear of the hardening machine, with solenoids controlling valves arranged to admit propane first to the burners and to close off oxygen first, thus avoiding any explosive or flash action at the burner head. Timing of gas flow is done with split-second precision, since the normal heating cycle is only a matter of seconds. Timers or "thermopiles" are used to cycle the burners, according to the part involved and the machine setup.

Design of burners and the flame pattern they produce are critical factors. In general, the burner heads, of copper alloy, cored for water cooling, are shaped to conform to the curvature of the part being treated, with drilled ports or inserted tips directing flames on the localized areas to be hardened. The zone of hardening may be varied by opening or plugging ports in the burner head. All the ports in any one burner are of the same diameter and usually clear the part surface by roughly ⅜ in.

It is claimed that depth of hardness is easily controlled within 0.020 in. by proper calculation of the number, size and location of burner ports, rate of gas input and the time the flame is applied. Should any ports become enlarged by heat corrosion after a period of time, they can be reamed and fitted with new plugs drilled to the correct diameter.

Control of the hardening machine cycle is fully automatic once a setup has been made, although there is a push-button panel convenient to the operator for separate actuation of individual elements of the cycle. Loading of parts into the heating position is done by the operator, except in cases where a magazine or hopper feed is feasible—as with such parts as camshafts, rocker-arm shafts and pushrods which will roll easily into position for automatic loading methods.

After the heating cycle, pieces are dropped off the fixtures or lowered mechanically into quench tanks located in the bases of the machines. Quenching oil is circulated by a pump through a heat exchanger, supplied with either steam or cold water, depending upon the action of a thermostatic control set to maintain oil temperatures in the 110 to 120° F. range. Inclined mesh belt conveyers remove quenched parts from the oil and deposit them on intersecting conveyers which transfer them to subsequent washing and processing operations in the production line.

Numerous safety features are incorporated in the design of the hardening machines, in addition to those already mentioned. For instance, machine elements close to the flame—burners, guides, flame heads, arbors, back panels, etc.—are cooled by internal circulation of water under 30 lb. pressure. If this pressure should fail, the machine cycle is interrupted

automatically. Again, if for some reason or other the gas flame should be extinguished while the fuel pressure is still on, the operation is automatically stopped until the difficulty is detected and remedied.

RING GEARS

To take a look in somewhat closer detail at how each of the five types of flame hardening machines functions, consider first the ring gear installation, shown clearly in Fig. 1. Two gears are treated at one time, these being mounted in tandem on a spindle which moves in and out of the rear panel of the machine. After the gears have been placed on the spindle fixture and the machine cycle started, the spindle moves the pieces out directly between the four burners, two on a side and each fitted with 30 tips set to leave a ⅝-in. flame gap. The spindle starts to rotate, the flame is ignited and the thermopile mounted above the gears obtains the tooth temperature.

This temperature information is fed to a recorder-controller which holds the heating to 1570° F., this limit being maintained within 5°. When heat is reached, the gas is cut off, the spindle retracts and a kickoff plate eases the two gears from the fixture so they drop into the quenching oil below. Resulting hardness on the gear teeth is Rockwell C-55; also the hardness pattern reaches just to the roots of the teeth but not below.

Gears are S.A.E. 1045 steel, roll formed from ⅝-in. square bar stock, with the joint electric welded and the teeth cut into the outer rim. They are hardened at a rate of four pairs per minute, or an equivalent production rate of about 400 to 450 per hr.

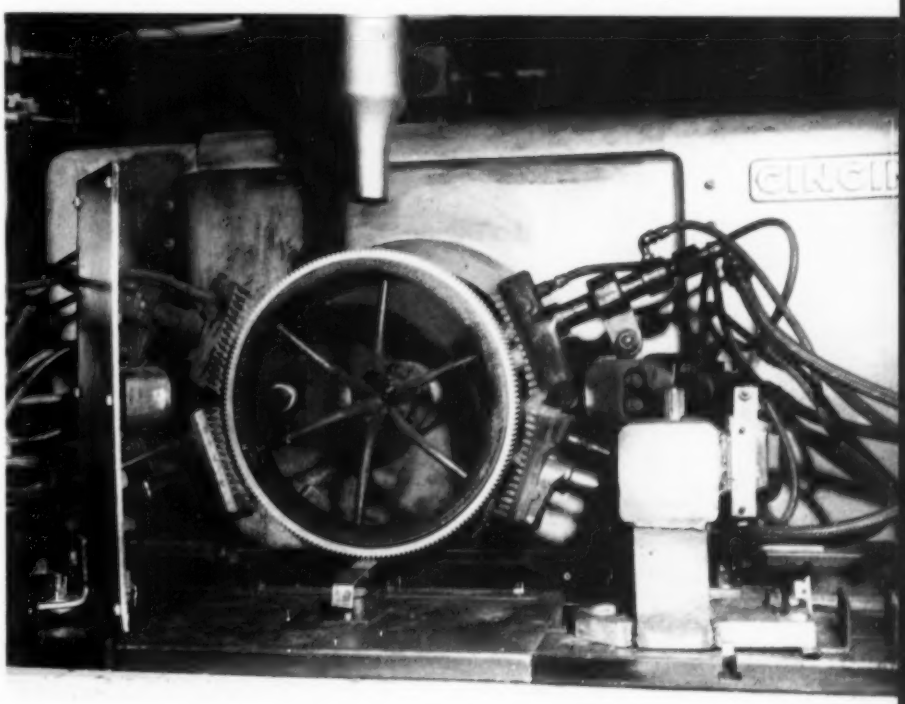
Two sizes of gears are handled by the machine, one having an o.d. of 14.636 in. and 146 teeth; the outside diameter of the other is 15.169 in. and it has 180 teeth. A change from one size to another is quickly made by changing the fixture on the spindle and moving the burner heads through the action of a feed screw. It will be noted that the entire assembly of burners and supports is attached rigidly by bolts to the heavy slotted table of the machine.

An unusual feature of this machine, not found in any of the others, is the arrangement for igniting burners by means of electric arc rods which, at the start of the cycle, advance from the rear panel until their ends are close to the burners when an arc is struck to ignite the gas. The rods then retract out of the way. The gears do not need straightening after heat treatment.

CAMSHAFTS

Camshafts are of gas carburized S.A.E. 1016 steel, and are flame hardened on the 16 cams and five bearings with a 27-sec. heating cycle at a temperature of 1475 to 1500° F. Figure 2 shows a shaft mounted in centers crosswise to the machine table. There are two banks of burner heads, each made up of four individual blocks, the faces of which are shaped to the

Fig. 1—Two Ring Gears Mounted for Simultaneous Hardening. Flames from the 120 tips of four burner heads heat the teeth as gears revolve. Funnel-shaped device at top is thermopile for measuring temperature of teeth passing beneath and controlling the flame cycle



100 Camshafts per Hr.

curvature of the shaft bearings. Holes 0.030 in. in diameter are drilled in the burner heads at suitable intervals to direct flames on the exact areas to be hardened. Water cooling keeps their temperature under 300° F., even when firing.

The fully mechanical handling of shafts through the cycle is briefly as follows: A ram lifts a shaft off an arm which has moved it from the loading rack. Centers advance from the machine panel and from in front to grip the shaft, the ram returning to the loading position. Burners advance to firing position and the spindle rotates the shaft at 125 rpm. Flames are ignited by pilot flame, and both thermopile and timer circuits are actuated. Whichever of the two reaches its limit first shuts off the gas, after which there is a 3-sec. delay to "stabilize" the heat, since the cam noses are at somewhat higher temperature on account of being closer to the burners.

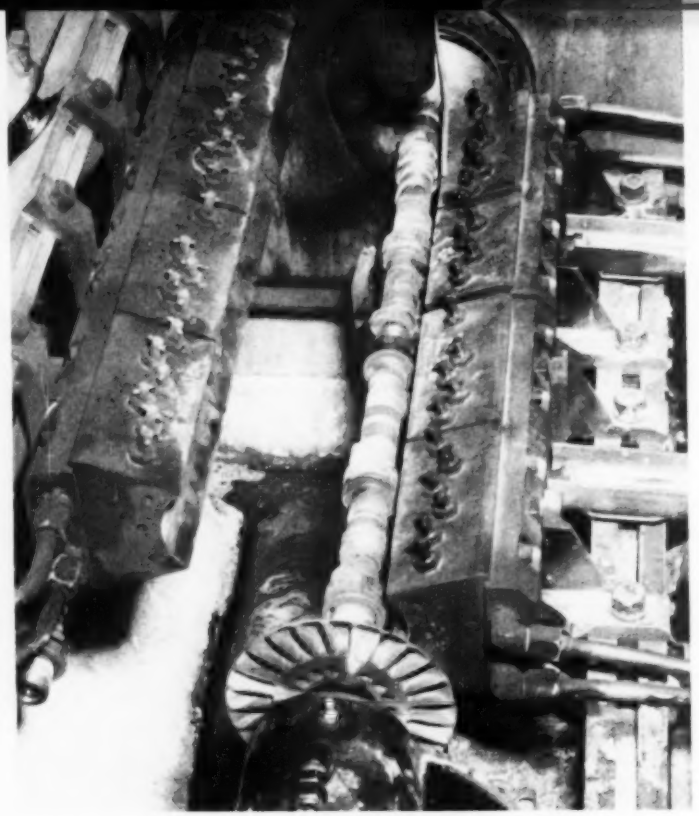


Fig. 2—Camshaft Is Held by Centers and Rotated as Flames Emerge From Burner Ports on 16 Cam Surfaces and Five Bearings. Left bank of four burner heads is retracted to show face contour. After heating and a 3-sec. delay for heat stabilizing, the shaft is lowered into a salt solution quench below and carried out of the machine by conveyer

Next the burner heads retract, and then the centers retract, allowing the shaft to drop to work stops which quench it into a salt solution. The latter is a mixture of 400 gal. water, 200 lb. sodium carbonate and 75 lb. sodium nitrate. This and the rocker-arm shaft are the only parts quenched in this manner, the idea being to increase the quenching rate. A conveyer elevates the shaft from the quench at the right side of the machine.

Production of 100 an hour is handled by each of two machines. Gas consumption is figured at approximately 26 cu.ft. per shaft, with hardened areas encompassing 73.5 sq.in.

PUSHRODS

Another unusual variation of the basic flame hardening machine unit and control cabinet has been worked out for heat treating the ends of pushrods (formerly fitted with cyanide hardened caps) at the high rate of 1900 an hour. It includes an inclined magazine feed which transfers the ¼-in. diameter rods to the teeth of two steel sprocket wheels 5 in. apart, these in turn moving the pieces through two "ribbon" burners playing on the ends of the rods and dropping them into an oil quench in the base of the machine (Fig. 3).

Water-cooled guides on either side of the 10-in. diameter 60-tooth sprockets keep the rods centered before they enter the burner flames. A moving 1-in. rubber belt bears against the rods to rotate them as the ends are being heated to insure uniform distribution of the heat. An air blast is directed against the belt to avoid overheating.

Burners are of the new "ribbon" design, only recently introduced in the U.S. The flame opening is a slot 2 in. long and only 0.028 in. wide. An arrangement of baffles inside the head, in combination with the carefully machined slot, produces a ribbon-type flame approximately ¾-in. long which is concentrated on the upset ends of the rods. The ends are roughly spherical in shape, ¾ in. in diameter. Hardness pattern may vary slightly from a minimum depth slightly over halfway through the upset end to

three-quarters of the way through. It is controlled by the gas mixture supplied to the burners, along with the speed of the sprocket. Time of exposure of the rod ends to the flame is no more than 2 sec.

The rods are of S.A.E. 1062 (modified) steel, drawn from coils of wire and cut to 8.75 in. long and upset simultaneously. Ends are hardened to Rockwell C-61 from a temperature of 1550 to 1600° F. As in other machines, they are removed by conveyer from the quench, the ends are ground slightly flat and the full length is centerless ground.

Burners are ignited by low-pressure pilot flames. Should the flame be extinguished for some reason, electronic flame control rods are positioned so a flow of raw gas will short them to close off the fuel supply.

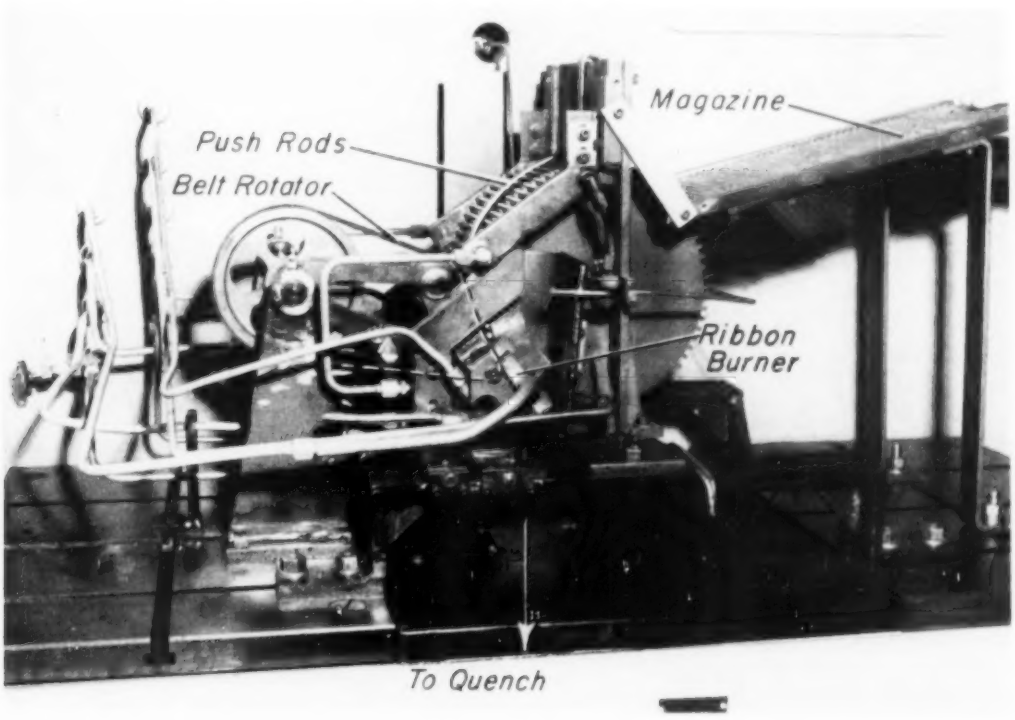
ROCKER ARMS

Slightly different types of machines, in which there is no movement of the parts being hardened, are the three installed for surface treating the two ends of rocker arms made of pearlitic malleable iron. The average hardness of these in their as-received condition is between Rockwell B-92 and 100; after treatment, hardness of pushrod seat and pad is Rockwell C-60. Seven arms are heated at one time and the heating cycle is 21 sec., giving production of approximately 800 an hour.

Fixturing of this machine, shown along with adjoining control cabinet in Fig. 4, is unusual in that it comprises two stations which are fired alternately, each mounting seven parts. One set of arbors is loaded while the other is being fired. Normally, one set is right-hand rocker arms, the other left-hand, although it is possible to run all of one type by a simple adjustment of stops which locate the arms as they are slipped over arbors holding them in position over the two burners.

Burners are small; the one firing on the seat of the arm has three ports and the one firing on the pad has four ports. Each, however, delivers the same B.t.u. to the area being treated, temperature averaging 1500° F. Following the

Fig. 3—Ribbon Burners of a New Design Are Utilized in This Setup for Hardening the Upset Ends of Pushrods. Rods feed into sprocket wheels from the magazine at the right. Wheels move in a counter-clockwise direction, carrying rods past continuously firing burners and into quenching oil below the machine table



Mechanization of Flame Hardening

21-sec. heating cycle, the seven arbors retract to kick off the arms into an oil quench directly below. The station to the right has an inclined chute to carry pieces to the deep oil and onto a divided conveyer which elevates them out of the quench at the right side of the machine to another conveyer, thereby keeping right-hand and left-hand arms separated for subsequent finishing operations.

There is no electronic control in this operation, the cycle being regulated by cam timers located at the rear of the machine panel.

ROCKER-ARM SHAFTS

Two machines are operated to handle hardening of eight "bands" on rocker-arm shafts. They are practically identical with the camshaft installations, except that there is no delay in quenching after the burner heads retract, since the section is uniform. The shafts are of gas carburized S.A.E. 1016 steel tubing, 19¾ in. long, 7/16-in. i.d. and 7/32-in. wall thickness. Four burners, drilled to direct flames on the areas over which the rocker arms fit, advance from either side of the shaft as it turns on centers. Handling is fully automatic, with a heating cycle of 17 sec. and average production of 180 per hour per machine. Heating temperature is set at 1600° F. and hardened sections are Rockwell C-50. Depth of penetration averages 0.040 in., and gas consumption 9.5 cu.ft. per shaft. Hardened area totals 23 sq.in.

Summary—Mechanization of flame hardening processes has resulted in accurate control of the selective surface hardening of automotive engine components, along with speed and safety, ease of equipment maintenance, and reduced requirements for floor space for hardening equipment. Highly important, too, is that basic types of machines and controls can be adapted to a broad range of differently shaped parts, with special fixturing, burner heads and handling mechanisms fitted to each. Five variations of the basic flame hardening machine are used for treatment of ring gears, camshafts, pushrods, rocker arms and rocker-arm shafts at Buick Motor Div.

Hardness pattern may be controlled closely by correlating burner design and location, heat input of gas mixtures and time of exposure to flame. Even variable sections, such as those of a camshaft, present no serious problem in effective hardening.

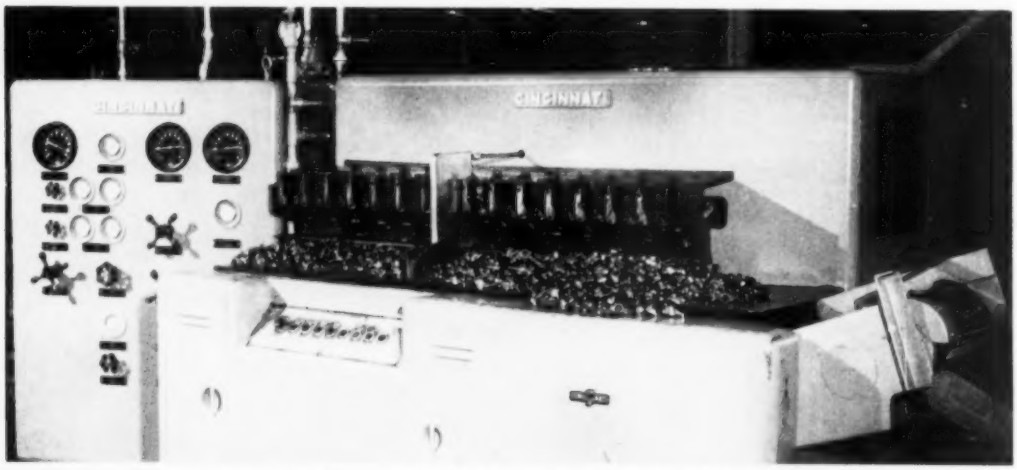


Fig. 4 Over-all View of Rocker-Arm Hardening Machine and Control Cabinet, Showing Two Groups of Arbors. Conveyer at the right elevates oil quenched arms from tanks in the machine base. Note push-button control panel

Oxygen-propane gas mixtures offer an ideal fuel for flame hardening under present-day conditions, although the usual safety precautions in piping, pressure regulation, metering, mixing and ignition must be observed. Devices such as electronic flame control rods, arc ignition rods, integrated relay systems and the like have added safety and certainty to flame hardening by machine processes. Incorporation of a variety of parts-handling mechanisms into the machine cycle has speeded up the process and minimized the need for operator attention. The equipment can be incorporated directly in the production line.

Some Aspects of Vacuum-Melted Metal

By J. H. MOORE
Director, Metallurgical Department
National Research Corp., Cambridge, Mass.
Now General Manager, Vacuum Metals Corp.

THERE ARE probably four basic effects of the reduction in atmospheric pressure over a molten metal which are being utilized in commercial vacuum melting. These are *(a)* simple protection against reaction with atmospheric gases, *(b)* dissociation of certain gas-metal compounds, *(c)* minimizing the amount of dissolved gas, and *(d)* acceleration of bath reactions which have gaseous products.

The usual vacuum refining treatment of a metal or alloy does not exploit just one of these effects, but two or more—although one of them may predominate. In the production of beryllium copper, for instance, while the simple protective action is instrumental in decreasing the beryllium loss from 10% to practically nothing, the more effective refining of the bath at low pressure gives a dividend in a completely effective content of alloy, undiminished by gas-metal compounds. Likewise, in such alloys as the nickel-base, age hardenable, high-temperature alloys, a major benefit is the avoidance of excessive loss of reactive hardening elements through oxidation. Particularly this is true when remelting scrap.

Utilization of the second advantage cited above—dissociation of oxides, nitrides, hydrides and certain other compounds such as sulphides —has limited possibility. If the common alloy bases, copper, nickel, cobalt, iron and aluminum are considered, it is evident that oxygen can be removed by dissociation of the contaminating oxides only from copper, nickel and possibly cobalt. The dissociation pressures of the oxides of iron and aluminum are much too low for practical vacuums to have any effect. All of the nitrides and hydrides of these metals can, however, be dissociated and the gases pumped off.

Considering those gases which do not form stable gas-metal compounds at the pressure in the furnace, the amount of gas in solution may be reduced. At equilibrium, a direct relationship exists between the amount of gas left in solution and the partial pressure of the gas over the melt. For oxygen, nitrogen and hydrogen, this solubility is proportional to the square root of the pressure. The dissolved gas content of a melt will thus decrease under continued pumping and approach this equilibrium relationship. Figure 1 shows this effect for nickel. In the same way, any element which is gaseous under the temperature and pressure existing within the furnace will be vaporized from the melt. Thus, in all the common metals, such elements as lead, zinc, bismuth, antimony, tellurium and selenium are decreased by vaporization.

This reduction in content of nitrogen, hydrogen and the elements with high vapor pressure is a function of all the vacuum melting practices, but is particularly important for copper and nickel alloys for use in electronic tubes.

Because most raw materials available in quantity and at low price are rather impure, particularly with respect to oxygen, the effect of vacuum on certain refining reactions can be very important. The best example is probably the reaction of carbon and oxygen in solution to form carbon monoxide. Since pumping is continually removing the product, the reaction is forced almost to its end. In practice, a problem is posed by the necessity for a close carbon-oxygen balance at melt-down to minimize both elements at the end point. If the oxide crucible is at all reactive, an added complication is introduced – namely re-oxidation by reaction between bath and crucible.

Figure 3 (p. 105) illustrates the reduction of nitrogen and hydrogen in high-purity iron during vacuum treatment. The reduction in carbon by the CO reaction may be seen, as well as a corresponding decrease in oxygen content – to a certain point. The complicating re-oxidation by the magnesia crucible is also evident. The actual data in this plot correspond only to a certain size of experimental melt and definite set of conditions, but they may be considered as representative of the general case. A careful study of the kinetics of such reactions has been necessary in the development of vacuum refining practices.

It has been noted previously that, in the melt-

ing and casting of most materials, most if not all of the four effects listed are important. For example, in the production of an alloy steel or high-temperature alloy low in carbon, the first stage of refining may call for the reduction of carbon and oxygen in the base melt by a controlled reaction, with simultaneous elimination of hydrogen, nitrogen, sulphur and phosphorus. The addition of reactive components can then be made without losing substantial amounts by reaction with oxygen in the melt. Further purification can be performed, particularly with respect to nitrogen and hydrogen, prior to tapping, and the vacuum protects the metal from contamination and losses through atmospheric reaction, both during final soak and teeming. The resulting ingot can then possess the five advantages of *(a)* soundness because of lack of gas evolution, *(b)* extreme cleanliness due to elimination of inclusions, *(c)* low content of gas in solution, *(d)* completely effective alloying by elimination of gas-metal compounds, and *(e)* controlled total alloy content by eliminating losses to oxides and nitrides during melting.

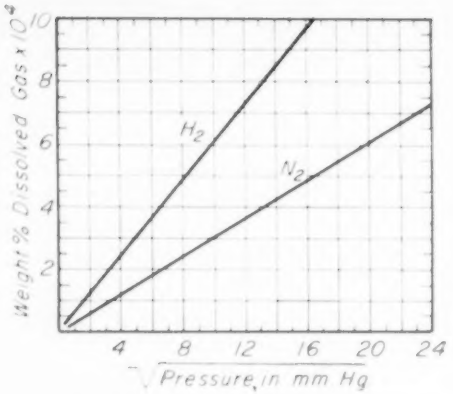


Fig. 1 — Effect of Pressure on the Amount of Hydrogen and Nitrogen Which Is Soluble in Nickel at 2875° F. (1580° C.)

PROPERTIES OF VACUUM-REFINED METALS

When metals and alloys are produced with such characteristics as just mentioned, technological properties may be pronouncedly changed, and an increasing flow of data on such matters is coming from work at National Research Corp. and several other laboratories.

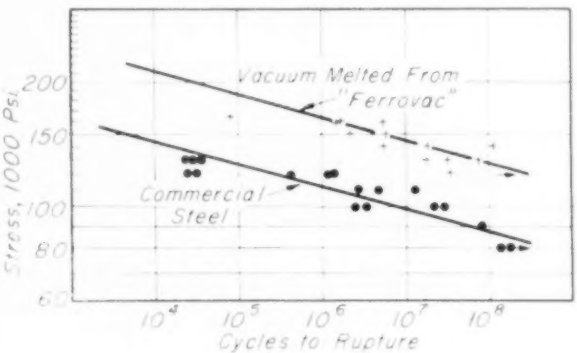
A prime reason for eliminating gas porosity in the ingot is, of course, to avoid surface defects such as blisters during the fabrication of sheet and strip. Gas-free metal is probably of greater importance in the production of shape castings, since there is no subsequent working to weld up internal cavities, and surface blemishes or internal porosity are usually irreparable.

Our experience indicates that the most frequent cause for gas evolution during solidification is not the simple decrease in solubility of a dissolved gas, but this effect combined with a reaction such as that of dissolved carbon and oxygen or of hydrogen and oxygen. In ordinary practice both reactions are inhibited by a strong deoxidation of the melt just before pouring. However, this is not always desirable — for example, in pouring castings of high-purity copper — where the presence of a strong deoxidizer in solution would be detrimental to electrical conductivity. Vacuum-melted copper can be cast to 100% I.A.C.S. conductivity and be completely sound as well.

The high degree of cleanliness obtainable in vacuum melting by avoiding slag inclusions and deoxidizers is of considerable interest. Certain alloys which are drawn to very fine wire can be fabricated with much less difficulty. Surface quality is greatly benefited; there are no inclusions to cause pitting, scratching, and consequent dulling of the finish or increase in coefficient of friction. A considerable improvement in rotating-beam fatigue life of high-carbon chromium steel is attributed to an increase in cleanliness which eliminated many subsurface as well as surface stress-raisers. The present author has compared the fatigue behavior of commercial 52100 ball-bearing steel to metal of the same analysis prepared in a vacuum furnace. Results were summarized in "Improvement in Fatigue Behavior of 52100 Steel by Vacuum Melting", *Iron Age*, April 2, 1953, from which Fig. 2 is copied. Marked improvement in transverse fatigue properties of 4340 steel has also been reported.

Very low gas content in solution at solidification has been shown to have important effects on metallic properties, although the mechanism is not completely clear in all cases. The work of J. Hochmann

Fig. 2 — Vacuum Melted (Inclusion-Free) 52100 Has Markedly Better Endurance Than Commercial Alloy Steel of Same Analysis



on 25% chromium-irons* and of W. O. Binder and H. R. Spendelow† on plain chromium steels, for instance, has shown clearly that it is the amounts of carbon, nitrogen and oxygen that determine the ductility of chromium-irons, high in chromium, although there was some disagreement as to the relative importance of oxygen. The effect on impact strength of decreasing the content of these impurities in the 25% Cr alloy is very marked, a value of about 100 ft-lb. being characteristic of the vacuum-melted steel, as compared with 0 to 8 ft-lb. for the commercial product.

Recent tests under the direction of Prof. N. J. Grant‡ at Massachusetts Institute of Technology have shown that a very low total of carbon plus nitrogen has a decided effect on the creep-rupture behavior of 18-8 stainless steel. An analogous steel, vacuum melted by National Research Corp., containing 0.006% total $C+N_2$, exhibited decidedly better creep resistance, rupture strength and ductility at 2375° F. (1300° C.) than commercial "extra low-carbon Type 304 stainless", thus:

	Vacuum Melted 304	Commercial ELC 304
100-hr. rupture stress	18,000 psi.	13,500 psi.
1000-hr. rupture stress	14,800 psi.	9,000 psi.
Reduction in area	42 to 75%	20 to 39%

Similarly, in work done under the author's supervision at National Research Corp. (not heretofore published), a decided effect of nitrogen content on the rupture strength of high-purity iron has been found:

50-Hr. Rupture Stress	0.009 N_2	0.0001 N_2
At 800° F.	10,200 psi.	16,000 psi.
At 900° F.	6,800	12,000

Minimizing the gas content in materials used in vacuum tubes has been found to give such improved characteristics that they are now being so made in Germany. It has been particularly beneficial in decreasing leakage of glass-to-metal seals, and in the rapid degasification of tubes.

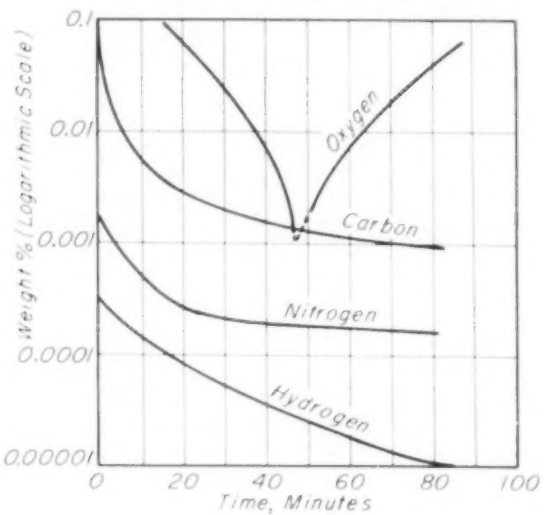
If a portion of a reactive alloying element can be tied up as inert oxides or nitrides, the effect can be particularly important in the age hardening alloys such as beryllium-copper, chromium-copper and the nickel-base series containing titanium and aluminum as hardeners. The proper use of vacuum melting greatly decreases the amount of alloying element tied up in this manner, thus increasing the uniformity of the alloy's response to heat treatment.

The advantage of closely controlled alloy content is being pursued particularly in electronic alloys such as those for cathodes. The emission characteristics of the oxide-coated cathodes appear to be quite dependent on very small amounts of alloying elements or impurities. Vacuum melting gives the necessary degree of control and is used for this reason in German production, and to a small extent in American. Expansion alloys and magnetic alloys are other types in which composition control, usually critical for proper performance, is being improved by vacuum melting.

The principal metals and alloys now being vacuum melted in this country or in Germany are electronic tube materials, sealing alloys, magnetic alloys, steels for high fatigue and impact strength, and expansion alloys.

In Germany, the production of such vacuum-melted metals is about 16 tons per month. No estimate can be made of the capacity of American facilities, since most of them are either classified or used in research; they are operated by the electrical industry, the Atomic Energy Commission, and by certain specialists in industry. Our plant alone can make about 60 tons a month of a material like electronic copper, and 15 tons a month of steel or high-temperature alloy. The products require a sizable price premium, largely because of the small volume and large diversity of products. However, as an alloy becomes established as a standard product and gets into tonnage production, the prospects of cutting this premium to a fraction of the present level are excellent.

Fig. 3—Experimental Curves for Degassing During Vacuum Melting of Iron in a Magnesia Crucible

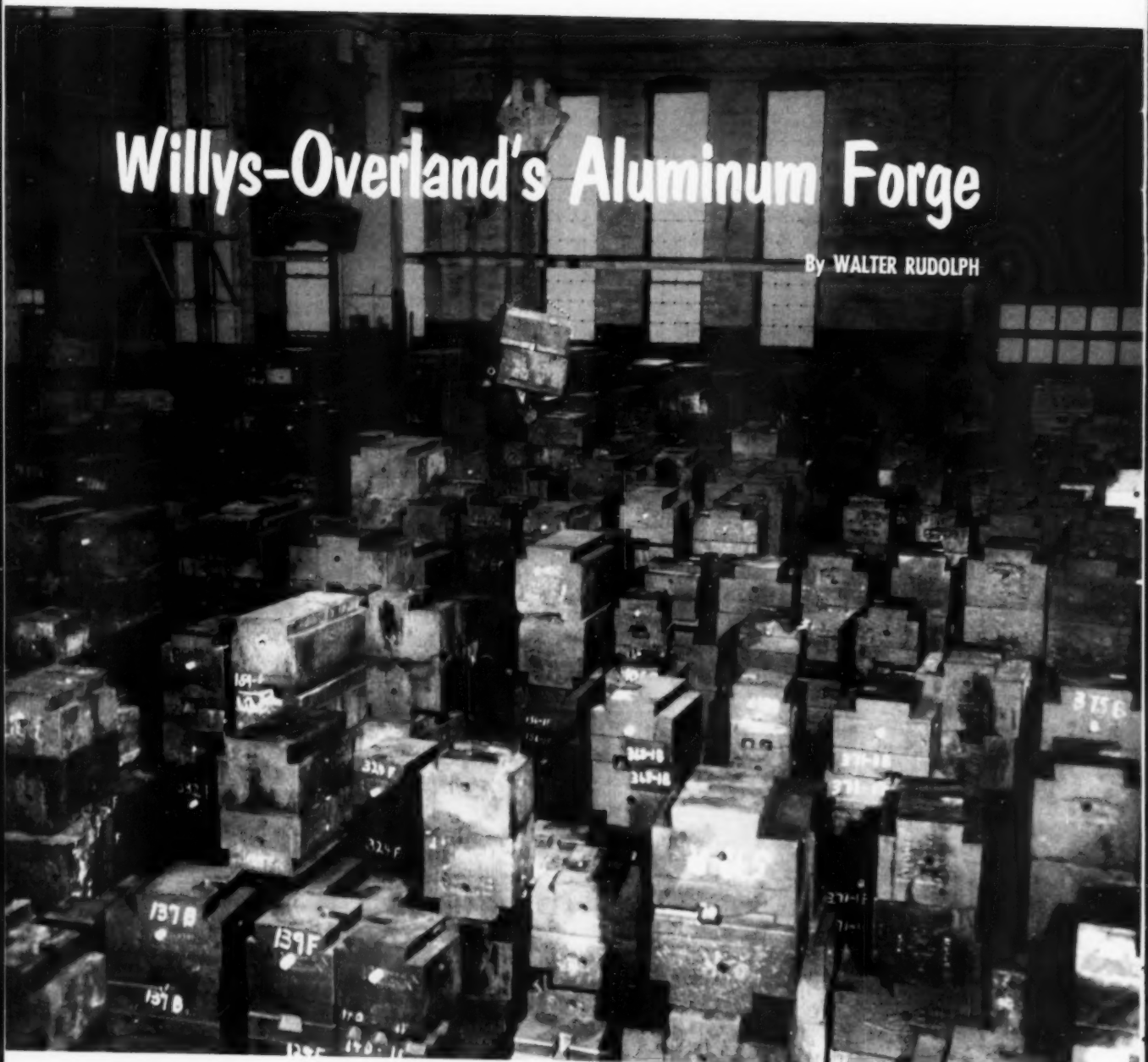


Effects on Fatigue and Rupture Strength

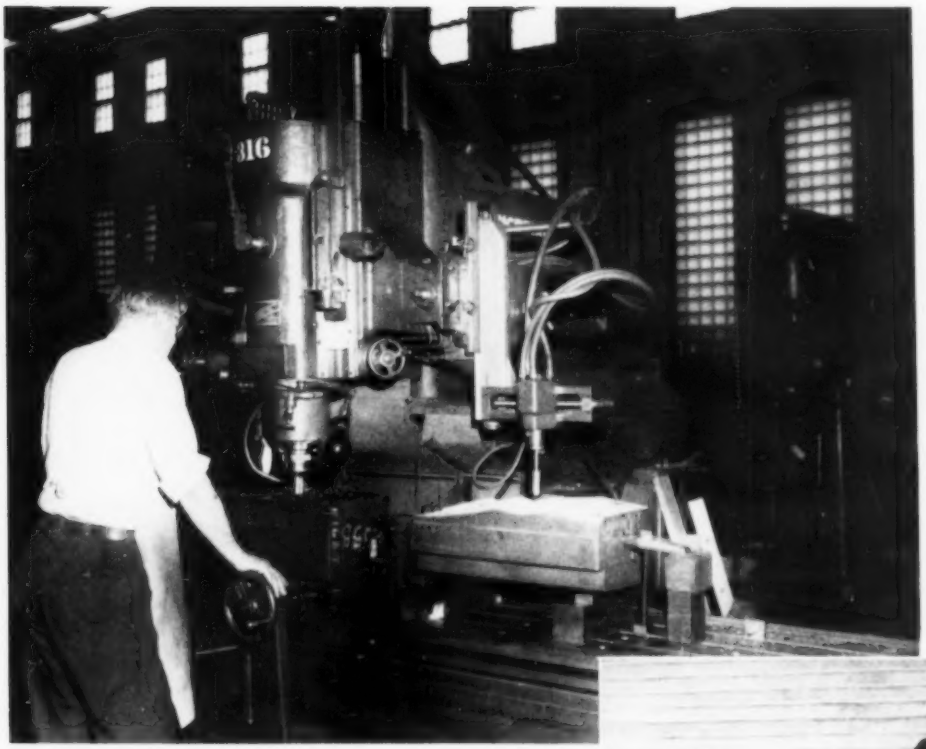
Revue de Metallurgie, Vol. 48, 1951, p. 734.
†*Transactions* of the ASM, Vol. 43, 1951, p. 759.
‡*Transactions* of the ASM, Vol. 45, 1953, p. 105.

Willys-Overland's Aluminum Forge

By WALTER RUDOLPH



LAST YEAR Willys-Overland Motors of Toledo, Ohio, reactivated and modernized an aluminum forging plant in Erie, Pa., as its Aluminum Forge Division. The somewhat antique structures enclose one of America's largest and most up-to-date forging operations, turning out about 1,000,000 lb. of completed forgings monthly—some for automobiles but mostly parts for aircraft fuselages and engines, fuse caps, missile fins and rocket blades, ranging in weight from half an ounce to 90 lb. and in size up to 42 in. The view above shows an almost endless array of dies, stored against repeat orders.



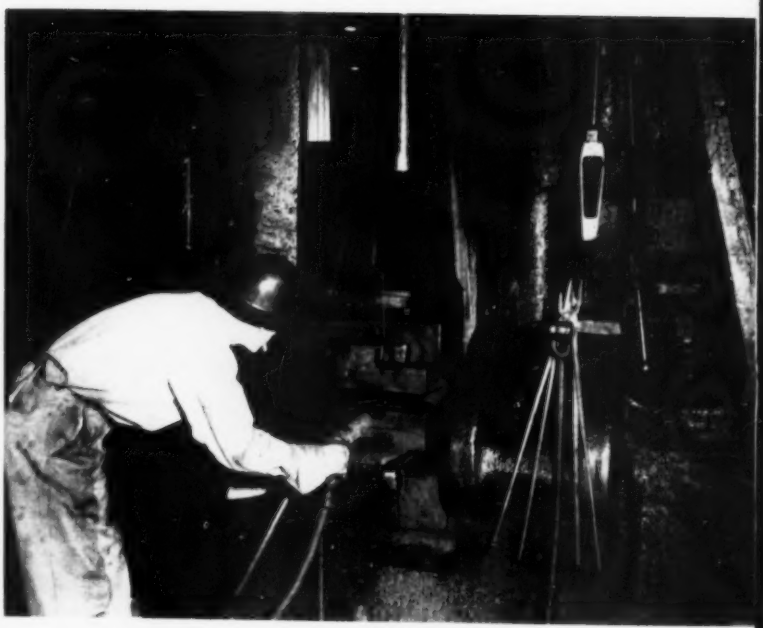


THE DIE division runs in straight line from engineering, die sinking to die finishing. On receipt of specifications, Willys-Overland engineers design the die and drawings are released to the shop on receipt of the order. Diversity of the work is such that, even on two shifts, 100 men can hardly keep up with the orders. Some 40 major machines do the work, including Cincinnati "Hydro-Tels" (shown above), Pratt & Whitney Universal Oscillators, shapers by Ohio Machine Tool and Eberhard, surface grinders by Hill-Acme, Thompson or Hanchett Mfg. Co. These are for the actual shaping of the dies; the blocks get their general shape in the stock preparation room by Motch & Merryweather billet cutters, Armstrong-Blum metal saws and Fosdick radial drills.

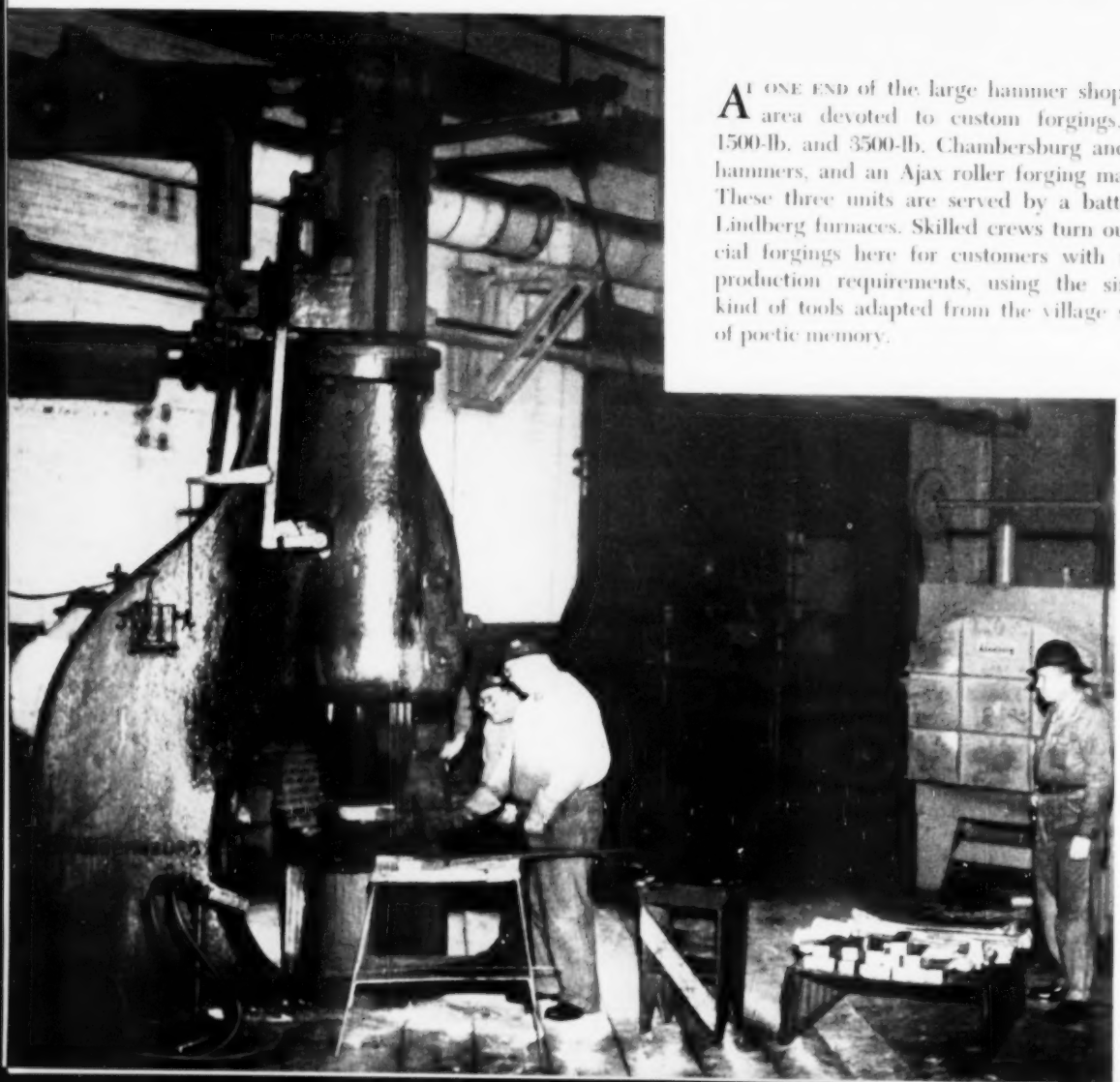
A little hand finishing (right) is inevitable. Workmen rely almost exclusively on air powered Aro or Dumore grinders or polishers whose speeds range from 3400 to 22,000 r.p.m. Very little hand filing is necessary. Each bench has its own dust collector.

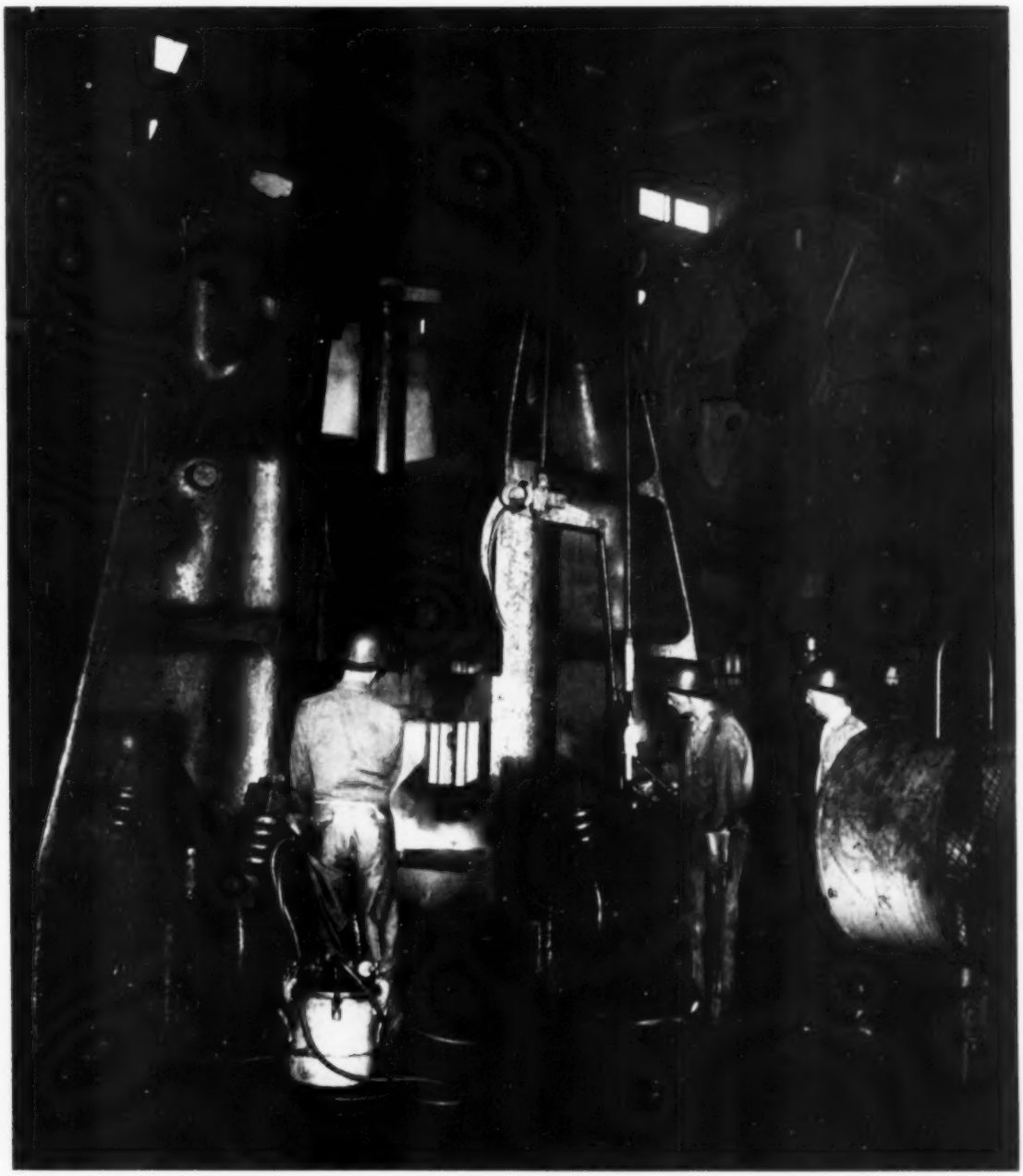
Hammers

A PLASTER CAST or lead casting from the completed die is sent to the customer for dimensional check. In many instances this is followed by a trial run, making enough completed forgings so Willys-Overland and customer's engineers and metallurgists can examine the product from every angle. Starting from cold, a portable burner, gas fired, plays a flame into the partly opened dies, heating them mildly to prevent damage to these expensive steel blocks; parts have higher precision, dies are less likely to flake.

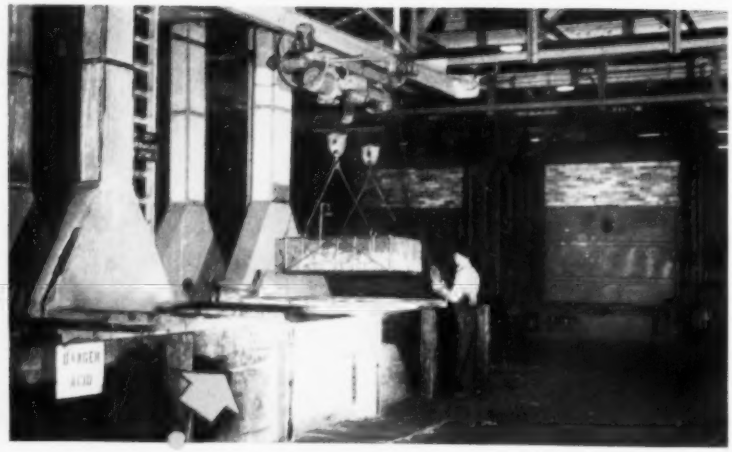


AT ONE END of the large hammer shop is an area devoted to custom forgings, with 1500-lb. and 3500-lb. Chambersburg and Ajax hammers, and an Ajax roller forging machine. These three units are served by a battery of Lindberg furnaces. Skilled crews turn out special forgings here for customers with urgent production requirements, using the simplest kind of tools adapted from the village smithy of poetic memory.





THERE ARE 26 hammers and five presses operating at Willys-Overland's Aluminum Forge Division in Erie, Pa. Hammers range from the 1500-lb. open frame steam hammer shown on the left-hand page to the 20,000-lb. Chambersburg hammer (above), Erie Foundry Co.'s hammers, Ajax presses, and National "Maxipresses" complete the battery. The large hammer shown above (with a press dimly at its right) is in action. While the forger and his helper stand by, the oiler blows a mist of lubricant over the warm dies from the DeVilbiss apparatus just behind him. "Propellair" fans, as at right, are scattered all about the shop, everywhere a crew needs to be protected from heat, smoke or fume. Billets are heated in gas-fired Surface Combustion furnaces—some (for long production runs) of through type.







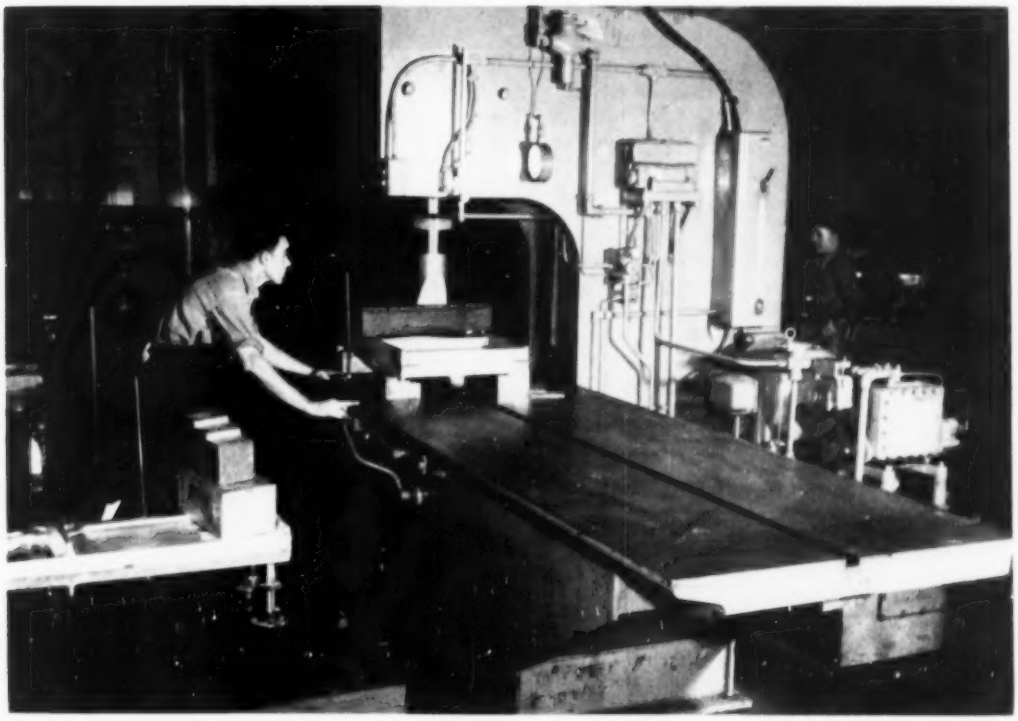
FORGINGS are transferred in large steel tote boxes by Elwell-Parker fork trucks to the "Chip and Mill Department", whose principal benches (flooded with light) are shown in the central view on this page. Flash is cut away by the band saws or presses along the right wall of this bay. Heat treating and pickling (at rear of benches—also shown in more detail at top of page), and final cleanup, deburring and polishing (left) are important operations. Favorites of the bench workers are Chicago Pneumatic and Aro hand tools. Dust from each wheel is drawn away by individual Roto-Clone machines.

Finishing



VARIETY of work handled by Willys-Overland's Aluminum Forge Division is great and runs are ordinarily rather short; an economic balance requires that most forgings be cleaned of flash by band saws. A battery of five Tannewitz saws is seen dimly at right of the chip and mill benches. Alongside them are four Minster presses for trimming small forgings produced in sufficient quantity to warrant manufacture of trimming dies. Dual-spindle grinders made by U.S. Electrical Tool Co. are very useful for removing excess metal along the parting line.

CUSTOMER'S SPECIFICATIONS govern the finishing operations. Accurate solution treatment and aging is performed in General Electric furnaces. Pickling is valuable to disclose occasional surface defects. Some forgings are restruck after trimming to improve dimensional accuracy. Others—long and spindly, or flat and blocky—are straightened to correct any warpage after heat treatment, as is shown in the K. B. Wilson hydraulic table below.



Analysis and Correlation of Test Data

By IRVING W. BURR,
Professor of Mathematics
Statistical Laboratory
Purdue University, Lafayette, Ind.

WHENEVER WE HAVE results which vary from time to time, piece to piece, test to test, or person to person, we have "statistical data" whether we like it or not and whether we know it or not! Having such statistical data, why should we not use the methods designed primarily for analysis of such data—namely, statistical methods?

Do you have random variation in your experimentation or inspection? If you are measuring precisely enough, you do. If so, then you can use statistical methods to gain more assurance in your operations and in the analysis of your results.

"What kinds of errors can I make in analyzing data?" You ask. You can draw conclusions not warranted by the data, or miss a sound conclusion which can be drawn from the data and which should be found. Statistical methods can cut these risks, or at least tell us what risks we are taking in making a decision. Life is full of risks; let us assay them and know what they are.

Random Sampling—One of the basic elements of statistics is random sampling. If we want to learn something about how a certain metallurgical process works, we take a random sample from pieces, observations or tests made under those conditions. For example, we take a *random* sample of the castings in a lot or box. We do not proceed as a friend of mine did, when he drew up 100 piston ring castings from a lot of 3000 and found 25 bad ones among the 100, so he sorted the other 2900. How many additional defectives do you think he found? You're wrong—only four more. Was the sample a random one? No. Not once in history would such a misleading sample arise *by chance alone*.

To draw a representative sample, it is usually best to let chance do the work. This is better than trying to steer the sampling, trying to draw some high and some low and many in the middle. And of course it is much better than drawing with an unconscious or conscious bias.

Random sampling, however, is not mere unplanned haphazard drawing. It is not that easy; random sampling requires care and planning. If the pieces can be thoroughly mixed, do that and "shop around" for pieces without looking. Or if they can be laid out in a row we can use random sampling numbers. Dice (if unbiased!) and shuffled cards can also be used. The idea is to try to give every piece the same chance to get into our sample. (The same applies to the results of a series of tests or any series of quantitative observations.)

The Idea of a Distribution—Any series of varying results coming from one more or less constant set of conditions can be formed into a "frequency distribution". Thus, if we have the hardness of a series of heats of steel made to a single specification, such as C-50, C-53, C-53, C-52 . . . , we can count how many

Table I—Quenched Hardness of 331 Heats of 4032H and Computation of Variability (Sullivan)

(Use of Long Method Following Definition)

Rockwell Hardness	Number of Heats	Difference From Mean	$n\times^2$	
C-59	1	+7.4	$1 \times 7.4^2 =$	54.76
58	0			
57	0			
56	5	+4.4	$5 \times 4.4^2 =$	96.80
55	14	+3.4	$14 \times 3.4^2 =$	161.84
54	34	+2.4	$34 \times 2.4^2 =$	195.84
53	64	+1.4	$64 \times 1.4^2 =$	125.44
52	66	+0.4	$66 \times 0.4^2 =$	10.56
51	61	−0.6	$61 \times 0.6^2 =$	21.96
50	46	−1.6	$46 \times 1.6^2 =$	117.76
49	18	−2.6	$18 \times 2.6^2 =$	121.68
48	13	−3.6	$13 \times 3.6^2 =$	168.48
47	4	−4.6	$4 \times 4.6^2 =$	84.64
46	1	−5.6	$1 \times 5.6^2 =$	31.36
45	1	−6.6	$1 \times 6.6^2 =$	43.56
44	2	−7.6	$2 \times 7.6^2 =$	115.52
43	1	−8.6	$1 \times 8.6^2 =$	73.96
	331		$\Sigma(\times)^2 =$	1424.16

Range C-43 to C-59
Median value C-52
Arithmetical mean C-51.6

Standard deviation σ

$$\sqrt{\frac{\Sigma \times^2}{n-1}}$$

$$\sqrt{\frac{1424.16}{330}} = 2.08$$

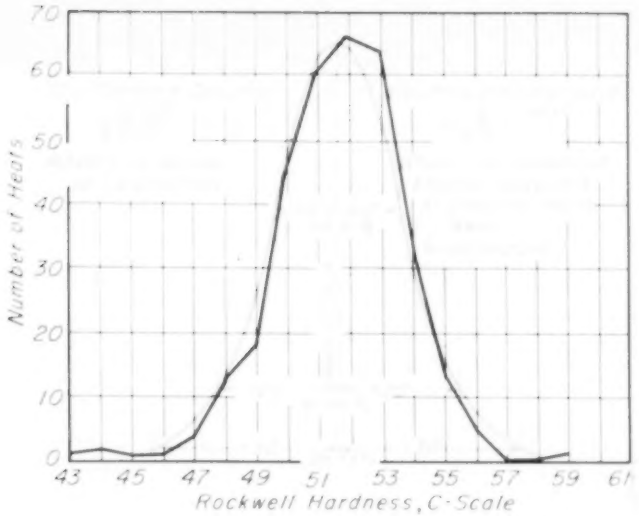


Fig. 1—Frequency Polygon of Hardness Data in Table I and (in Color) Normal Probability Curve (Sullivan)

of each we have and thus form a frequency distribution. There is likely to be a commonest hardness (which a statistician would call the "mode", C-52 in Table I) and the frequencies would fall away in both directions, in a more or less symmetrical manner. A graph of such a distribution shows how the hardnesses "run", and if they depart far from the mathematical curve of error or the "normal curve", the heat treating operation or the method of test may be worthy of study or special methods may be needed. Something is out of control.*

Population Versus Sample—We now must consider two distributions. First is the distribution we actually did get from the hardness tests of Table I; this is the "sample distribution". On the other hand, we can at least think of the distribution of an indefinitely large number of such analyses. This is the "population distribution"; ideally or theoretically it is represented by the "normal curve" in color in Fig. 1. The problem of the relation of sample to population is the central problem of statistics. What does the sample tell us about the "true situation" under a given set of conditions?

Size of Sample—Unfortunately it takes a rather large sample to tell us much about the "shape" of the population distribution; over a hundred measurements may be required. But most fortunately we do not need anything like that many to tell us useful information about the average and the variability of the population. Thus (as will be developed in detail in John Sullivan's paper to be published later in this series) if we have 12 heats of openhearth steel made under a certain practice, we could say that we are "90% confident" that the true yield under this process lies between 78.57% and 79.69%, and also "90% confident" that the true standard deviation lies between 0.65% and 1.38%. (This is based on actual data.) I have chosen "90% confidence" arbitrarily; we might want to be "95% confident"; on the other hand, perhaps "85% confident" would do. The "confidence band" for true yield would then be respectively wider or narrower.

*A good example was contained in the fourth lecture of the Philadelphia Chapter's series by John W. W. Sullivan, and is used here as Table I and Fig. 1. Jominy end-quench tests for 331 heats of 4032H steel were available for analysis, and Table I lists the hardness (Rockwell C-scale) 1 16 in. from the quenched end and the number of heats giving that hardness. The frequency (number of heats) is plotted against individual readings in black in Fig. 1. This is known as a "frequency polygon". Superimposed in color is the mathematical curve of error or "normal curve" computed from the data in Table I. The fit is fairly good.

This question was raised in the discussion after Professor Burr's lecture: "Suppose the experimenter gets ten sets of numbers representing hardness. Most of them cluster around 65 but one reading is 47 and one reading 53. Usually he just throws these low ones out as erroneous and takes 65 as the average. What should he do statistically?"

Professor Burr replied: I would be much more willing to throw them out if I had really suspected the off-data all along for experimental reasons. However, if I had no justifiable grounds then I would require a lot more stringent statistical conditions. For example, suppose we have four measurements, and one seems to be considerably off from the rest. One possibility is to take the standard deviation of the four measurements and find how many of these standard deviations the one measurement is away from the average of the four. It can be shown that no one such measurement (out of four) can ever be more than two such standard deviations from the mean of the four (since that one greatly inflates the standard deviation). Another possibility is to find the standard deviation of the three "good" measurements and then find how far from their mean the one "bad" measurement is. If this is more than two or three times the standard deviation of the three, they would throw the one away. Actually they should require about 8 or 10 rather than 2 or 3 standard deviations. Whenever one throws away measurements without sound statistical cause, he is giving his data the appearance of more reliability (repeatability) than they have. I suspect that many measurement errors especially in analytical work are underestimated this way.

In this second article, drawn from the 1952 Educational Series of the Philadelphia Chapter ASM, Dr. Burr removes a lot of the mystery from the statistician's jargon. (Maybe a statistician would look as blank when he heard "isothermal transformation" as a metallurgist would on hearing "multiple correlation".) But the author does far more than define terms—he indicates how an experimental program should be planned to get data of least ambiguity and how to use such data to draw conclusions having the maximum degree of certainty. The next articles in the series will apply the general principles to definite problems in nonferrous and ferrous metallurgy.

Such conclusions are useful in analyzing laboratory or test results. They do, however, depend upon several assumptions. First, we must assume that the data are "well-behaved", that is, came from a normal population. Second, we must be sure that the data we have come from a random sample. Finally, the confidence limits (in the example chosen—openhearth steelmaking) only apply to the population of heats made under the conditions obtaining when these heats were made.

A second approach which could be used is just the reverse of the foregoing. We ask whether the sample can, within reason, have come from some acceptable population. If, in the past, the average yield from standard practice has been 78.0% and the standard deviation has been 1.30%, can we reasonably get results such as we did from those same established manufacturing techniques? By simple statistical methods we could learn that the observed mean of 79.13% is significantly above a past yield of 78.0%, while the observed standard deviation of ½ (0.65 + 1.38) or 1.02% is not significantly below the past 1.30%.

Two Samples—What can we do with two samples? This is a most typical problem in the laboratory and in production. We want to compare two processes, formulas, measuring techniques, or shifts, so we take a sample under each set of conditions, holding everything else constant insofar as possible. Then comes the comparison.

Without statistical knowledge, all that some people do is take one measurement under each condition and then subtract. This does beautifully *provided* that there is very little random variation. But do we know this? Usually not. And in any case it is usually desirable to measure the variability for the data at hand. We can then use the "significance of difference" technique on the problem and thereby make proper allowance for the effect of random variation. Variability of two sets of observations may be compared by computing the F ratio, as indicated by Mr. Youden in his first lecture in this series (see *Metal Progress* for September p. 91). If random variation is comparatively large (relative to the actual true difference between the conditions) then we cannot safely say that there is a true difference, unless we have a lot of data. On the other hand, even if comparatively little data are at hand, we may still be able to conclude reliably that there is a real difference in the conditions if random variation should be comparatively slight relative to the true difference.

In any event, statistical methods can be used to give us two kinds of answers. First, we can draw the conclusion that there is a real difference (or that there is insufficient evidence of any real difference). Second, we can set limits on the extent of the true difference.

Either of these types of answers can be given, subject to a predetermined probability risk of a wrong decision.

As a specific example, we return to the study of steelmaking mentioned above. In an actual operation, heats melted under the standard and a proposed practice were alternated until data on nearly 50 of each were accumulated. Since the yield was averaging consistently 2% greater for the proposed practice, it was adopted. But after only five heats had been made there was very good evidence in favor of the change; after ten of each there was extremely conclusive evidence in favor of the change. There was no need to run the study up to nearly 50 of each *provided* (and this is important) the first ten heats of each were melted under typical plant conditions. Since they were, lack of statistical knowledge by the experimenters did cost the steel company a 2% yield on about 40 heats on this one furnace alone.

Several Samples—We get into the heart of industrial experimentation and research when we come to the matter of several samples. First there are the many kinds of "control charts" available to handle all kinds of industrial data. With some ingenuity they can be made to solve a great variety of problems. Their aim is to test whether the data could all have readily come from one population or whether there is reliable evidence of significant trends or assignable

causes. Briefly stated, the control chart compares each sample with the whole collection of samples or else compares it with some accepted standards.

With a somewhat different emphasis, analysis of variance asks whether the variation *as a whole* between samples (groups of data) can be attributed to chance. If so, then there is no evidence of any real relationships; if not, then we have evidence of some real causative influences in the data.

The number of possible designs which can be used for experimentation is large. One could easily write many articles rather than a few paragraphs on the subject. One of the most important developments is that several of the possible causative variables may be varied simultaneously in the same experiment, but in different combinations. In this way the separate effects of each are obtained independently of the others. Moreover, the joint effect of two or more of the causative variables may be found.

Consider the following hypothetical data on some physical property, high values being desired. The four "cells" 50, 80, 70 and 65 are averages of the measurements of the physical property when two principal factors, Element

		← Element A →		
		Low Level	High Level	
Element B	(Low Level:	50	70	Average 60.0
	(High Level:	80	65	Average 72.5
		Average 65.0	Av. 67.5	

A and B, are at high and low levels respectively.

If, in a study of the effect of Element A on the physical property, during which Element B was either uncontrolled (or else taken at the two levels but the data not kept separate), it might be concluded from the averages 65.0 and 67.5 that Element A is unimportant in the physical property. If we therefore held Element A at the "high" level because the average was a bit higher, then our experimentation on Element B's effect would get us to the figure of 70, rather than 80 which is actually attainable. If we happen to choose "low" for Element A, then we will reach the 80 combination if we keep Element B on the high side, but we may still not know enough to retain Element A at low, since it was apparently rather unimportant.

The best way is to take data under each of the four possible combinations, preferably making the same number of measurements in each category. We can then estimate the effect of three influences: Element A alone, Element B alone, and the interrelation of Elements A and B (which is what we call the "interaction"). Doubtless, some people would say "Any fool would use the four combinations and get the correct conclusion". Perhaps so, but some pretty wise men have failed to do so on occasion. In our particular example there is still the question as to whether the figure of 80 really is to be counted upon, or whether the observed averages in the four cells could all come from a single "population". If all the within-cell variation (for example, the variation around the average of 50 when both elements are low) is small enough, then all of the apparent trends to be deduced from the figures are significant. But if a within-cell variation is relatively large compared with the variation among means, then there may be no real evidence of true differences in the data, and all the apparent trends may be entirely a mirage.

In such instances statistical methods tell us what evidence we have in the data, what we can reliably say about them, and what we cannot bank upon. The fuzzy borderline cases cannot be safely handled without resorting to statistical methods.

The second point to make to those who believe commonsense is sufficient in appraising experimental data, is that the above example is the simplest one possible. What would the "commonsenser" say to a proposal that 64 measurements be taken under appropriate combinations of six different causative variables, from which the answer to 62 different questions involving direct effects and interaction effects of the six variables upon the characteristic under study?* Sound reasoning and drawing of conclusions simply is not easy (or, to put it another way, sound reasoning has developed the mathematical field popularly known as statistical analysis). Hardly any of our formal training has been on this problem. Conventional programs in mathematics, physics, chemistry and engineering do not train people in statistical thinking.

*An instance which comes to mind doubtless has many similarities in the metals industry, although it occurred in a study of production methods for penicillin. Six variables were to be taken into account. The investigators used only two levels of each, thus giving them 64 combinations of variables. They found a significant fourth-order interaction, which involves a combination of five variables and this led to the best combination of the five. That experiment was worth a half a million dollars. How many separate experiments would you have had to make, working on one variable at a time, to find that combination?

Designing an Experiment

There are three things we can do with suspected causative variables in designing an experiment. One is the time-honored scientific aim to hold all variables constant but two and then study the relationship between these two. This often misses the mark because of a significant interaction, as we saw in the previous section. Moreover, it is uneconomical, since in a very real sense it wastes data, uses each measurement very inefficiently and leads to an almost never-ending string of inconclusive experiments. Finally, it is often very expensive and difficult to hold variables constant. It is, of course, often desirable to hold some variables constant, such as personnel and test sets.

The second thing we can do to suspected causative variables is to hold them at carefully chosen levels in appropriate combinations. This is effective and leads to efficient use of each measurement. It may be expensive to hold the variables at those various levels, but we are getting our money's worth!

The third thing we can do is "randomize" the effects of a possible causative variable—if we cannot readily control such a variable we try to neutralize its effect by letting its values vary at random. This is not always easy to do but, if practicable, it is an excellent way to get around a serious difficulty.

What we usually do is to try to design an experiment using a combination of the latter two alternatives. We choose two or more of the possible causative variables to be controlled at certain agreed-upon and practical levels, usually at equal intervals apart. Then we try to randomize all other variables which we think may have any influence on the dependent variable. (We may also hold some of these constant.) Suppose we are studying the effect of chemical compositions on the machinability of steel. We might use three levels of sulphur, three of manganese, and two different pouring temperatures. This would give us $3 \times 3 \times 2$, or 18 possible combinations. We would make the 18 heats and measure the machinability of steel from each. (This assumes, of course, that we know how to measure machinability with some accuracy!) The resultant data could serve to tell the separate effect of sulphur on machinability, and of manganese on machinability, and of pouring temperature on machinability. Furthermore, the data could tell something about the joint effect of sulphur and manganese, of sulphur and temperature, and of manganese and temperature on machinability. Finally, the *joint* effect of all three might be studied if there were several determinations for each heat.*

But now what of all the other variables in the steelmaking process, potentially influential upon machinability? Some of these we may well find we can hold constant. If so, fine. If not, then we should try to randomize them. The very least we should do is to randomize the *order* in which we make the different heats. Suppose, contrary to this, we run off all six of the low-sulphur heats first, then the intermediate-sulphur heats and finally the high-sulphur heats. Then if we have some variable, X, which has a steady trend, starting low and increasing as we go along in the campaign, we may well make erroneous conclusions about the three variables S, Mn and T° which we are examining. For example, if our testing technique steadily improves, the machinability may, because of this, tend to increase from the first heat to the last. But if sulphur has been simultaneously increased, we are likely to draw the conclusion that the sulphur was responsible. We say in statistical terms that the sulphur and laboratory technique have been "confounded", and we cannot determine which of the two is the real cause of the improved machinability.

To avoid this trouble we can randomize. This would be very easy in the example we have chosen. We merely randomize the order in which we do the 18 heats by first writing down a list of the combinations of variables to be used, and then deciding the order in which they will be run. One way is to put the numbers 1 to 18 on 18 slips of paper, shake them up in a hat, and draw them out one at a time. If the first slip is, say 11, then we use the first listed

*In the discussion at Philadelphia, after Dr. Burr's talk, the question was asked "How much work is it to analyze the data on this study of 18 ingots?"

ANSWER: That depends on the skill of the worker and the equipment he has. I knew of one group of persistent men and women who worked out 100 multiple correlations by longhand arithmetic. The results were so useful that they were furnished with a fully automatic calculator whereby one woman could do each job in about 5% of the time by longhand. In this specific study of 18 ingots a skilled operator with a good calculating machine could easily do the job with all cross checks in a single morning. Certainly the cost is not prohibitive.

How can you be sure the operator always punches the right button?

ANSWER: Some people punch more wrong buttons than other persons. But even the best make a mistake now and then. However, the routine plan in a multiple correlation is such as to provide numerous comparisons and checks. A large arithmetical error shows up immediately; small ones can be caught and eliminated before they do any harm.

combinations of variables for the 11th heat. This randomizes the other uncontrolled variables.

Such randomization is always a good precaution in any experimentation. Otherwise, we may conclude that a difference is due to a controlled variable when actually it is due to one of the uncontrolled variables which got mixed up or "confounded" with one of the controlled variables. This matter is so important that it warrants considerable space to emphasize it.

A couple of additional principles may be mentioned in passing. One is that our experimental conditions should be as similar as possible to those we plan to use in practice. If they are not, our laboratory conclusions may not carry over at all to actual practice. Those who have experience in pilot plant operations are very conscious of this principle. The second is that the success of our experimentation largely depends upon how close to the optimum conditions we choose the levels for the controlled variables. If they are not all close we may have to sneak up on the best conditions by successive approximations. Take care in choosing the levels for the variables.



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SIZE OF THE SAMPLE

The ever-present question, "How large should the sample be?" involves three other questions. First, "How strong an effect will the random causes have?" Put in other words, "What would be the standard deviation or measurement error for a long series of measurements taken under identical conditions?" (This is the variation we cannot get away from.) Second, "What is the probable difference due to assignable causes?" For example, how great a difference is likely to occur between two techniques of heat treating like carburizing in solid compound and carburizing in gas? Third, "How much reliance do we require in the results?" Do we need 99.9% confidence or will 90% be sufficient? When the answers to these three questions are approximately known we can guess at the required sample size.*

Unfortunately, answers to the three essential questions are often not well known and may be altogether unknown. In fact, the first two may be and often are the object of the experiment. But we need all three to estimate properly the required sample size. The usual procedure is to jump in with some arbitrarily chosen sample size which we can afford, and at the conclusion of the experiment we determine how much evidence we do have. If it is enough, fine; if not, we try to get more data. By now, however, we are in a better position to estimate the required sample size.

RELATIONSHIPS

Often we take measurements of several variables at one time (or for one heat of steel, for example). Then at another time (or heat) we measure each of the variables again. And so on. Such data are called "correlated data". Thus, we may want to study the relationship between percent of silicon and hardenability of steel.

* An actual occurrence, some 25 years ago, is a good example. The claims made by American Rolling Mill Co. concerning the corrosion resistance of its culverts were challenged by another maker of sheet steel. This other maker said, "We want to prove that ours is as good as or better than yours." So the Armco man said, "How much of a difference would we be looking for between our product and yours in either direction?" and they agreed upon an amount. Next he asked, "How much variation is there in the corrosion loss of your sheet steel buried in dirt and dug up three years later?" and they agreed upon how much variability there was. And finally he said, "About how much confidence would you want in your results—90%, 95% or 99%?" Then by means of a slide rule the Armco man determined how big a sample had to be taken. It came out that about 225 culvert sections of each manufacturer's product would have to be buried. The competitor decided it wasn't worth it! That's one good way to win an argument.

Use of Scatter Diagrams

As a first step plot a "scatter diagram". This is a collection of points, each of which represents data for one heat. For example, we may plot hardenability on the vertical scale and percent of silicon on the horizontal scale. Taking such data from perhaps 100 heats, we have a swarm of points. These points may tend to lie rather closely along a straight or curved line, in which case we say that the relationship is good. We can, however, get anything from a strongly linear pattern to a completely random "shotgun" pattern. In the latter case there is no apparent relation between the two variables.

You, as metallurgists, are warned not to be too easily discouraged by scatter diagrams which do not show a close relationship. Perhaps the basic reason why the relationships in much of your test data are likely to be rather poor is that your predecessors have licked most of the easy problems, thus evolving "standard practices" for metal producing, working and treating operations. Thus, with silicon held within such specification limits as 0.20% to 0.27%, there is bound to be a comparatively slight relation between silicon and hardness. But if silicon in the "steel" were allowed to vary from 0.1% to 5.0%, then there would probably be a very definite relationship between percent silicon and all the physical properties. Our predecessors found such relationships and narrowed practice ranges until the relationships in current practice ranges are what the statistician would call "quite poor".

Just here is where we need statistical methods to enable us to go further. We can use the "correlation coefficient", which gives an objective measure of closeness of the relationship between two variables. This correlation coefficient can determine which of, say, 18 or 20 different process variables and analyses are most closely related to a physical property. None of them may be really close, but the correlation coefficient tells us which of the variables warrant further study. Otherwise it is difficult to tell, by eye, which of a number of scatter diagrams shows the best (or least poor) relationship when all of them are rather poor. It provides an objective approach to this difficult problem.

We can go further too by using "multiple correlation". In this technique we study the joint relation of several independent variables to the one dependent variable in question. Thus, in one study on an openhearth operation, neither the melt-carbon nor the carbon-drop was at all closely related to tons-per-melting-hour. One might be tempted to stop right there. But by taking the two variables together, a much better relationship was obtained than would have been suspected from either of the separate relations.*

In general, analysis of variance requires that the potentially causative variables be controlled or randomized out. If, however, this is not feasible or economical, or we have some doubts about the success of our randomizing, we can still use the principle of "multiple and partial correlation", provided we have measured and recorded all of the variables when each observation was taken. By partial correlation it is possible to find the net degree of relationship between any two variables when the influence of all of the other variables has been removed. This gives us a powerful and adaptable tool to supplement analysis of variance. "Analysis of co-variance" combines both analysis of variance and of correlation.

Sampling Plans—Rather closely related to the analysis of a single sample discussed early

(Continued on p. 282)

*Question From Audience: What does the statistician do to introduce all the variables for multiple correlation or analysis of variance, and not just those the foreman may want in?

Answer: That's a "toughy" because the statistician must not get the reputation of being a smart boy from the outside who is going to come in and tell the foreman how to run his business. The main emphasis of a consultant or the statistician in the company must be that of a helper—someone who will help the foreman or production supervisor use statistical methods so that he can get more out of what he is doing. It is mostly a matter of "selling", in the long run; keep at it and try this and try that and try the other.

Most certainly, the very least that can be done at the beginning is to randomize out the influence of the collateral variables that you suspect. Then you might slip one in occasionally and not tell him you are doing this and then find out what happened. You might get somewhere that way, but the shopmen are pretty smart. You have to be very careful; you don't want them to lose confidence in you. Above all, the statistician must have perfect integrity. He must work for and deserve everyone's trust. But being less familiar with the operation, he is in a good position to find "blank" spots. By this I mean that people do things a certain way because they've always done them this way, and they don't even suspect some kind of an influence because they haven't studied it in five years. The tradition is that it doesn't matter. Yet we may find that one influence to be a potent source of trouble under current practice. We have to encourage people to have an open mind and to be willing to try all possible sources of trouble or improvement.

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A Signaller to Reduce Quench Cracking of Steel

To obtain the best combination of strength and toughness in steel parts, it is generally necessary that these parts have a microstructure of tempered martensite. This of course requires that the parts be given a heat treatment which includes heating into the range where austenite is stable and then a fast quench to a temperature low enough for the austenite to transform into martensite.

If the quench from the austenite range to the temperature of martensite formation is not rapid enough, the austenite will transform, during cooling, into undesired pearlite, bainite or proeutectoid constituents, instead of to the desired martensitic structure. On the other hand, if rapid cooling is continued to such a low temperature that some portions of the part transform into martensite much more quickly than others, the volume expansion accompanying this transformation may set up internal stresses great enough to crack the part. In production heat treating, quench cracking is, in fact, often a very serious problem. An obvious way to minimize quench cracking is to cool the part rapidly to just above the martensite range, then check the rate to a slow one through the martensite range, so that at any moment its entire cross section is at approximately the same temperature and thus will expand uniformly as the martensite forms. No macroscopic internal transformation stresses will then develop.

Unfortunately, no quenching medium is known which will cool a steel piece very rapidly at high temperatures and very slowly at low temperatures. Likewise, certain restrictions to the operation are placed by the *mass* of the part being cooled. Consequently, various expedients are resorted to. The most rapid cooling at high temperatures is attained with water, or with a dilute solution of suitable salts in water. Difficult parts may be quenched in water until they reach a temperature at which martensite formation begins, then removed from the water and permitted to cool more slowly through the martensite range – as in the open air or in an oil bath. The temperature at which the part is withdrawn from the water has been controlled by holding the part in water for a fixed time; this time is determined by preliminary trials on pieces of the same design.

Such quenching for a fixed time has several disadvantages:

1. The temperature at which martensite starts to form (the M_s temperature) varies somewhat from lot to lot of steel, due to variations in chemistry allowed within specifications for a single grade. To determine it experimentally for each lot requires additional equipment, expense, and delay.

2. Additional experimental or trial-and-error work is needed to determine the time necessary to reach the M_s temperature, even when the latter is known.

3. Most important, the quenching time to reach a fixed temperature is not constant but changes significantly because of fluctuations in the temperature of the water, the agitation of the water, accidental impurities or intentional additions in the water, the temperature of the part when quenching starts, and the amount and character of the oxide scale on the steel surface prior to quenching.

Accordingly, it appeared desirable to control the quench not by a clock, but by some indication – obtained directly from the part during the quench – that martensite is forming. The most promising approach, it seemed, would be to take advantage of the fact that martensite is ferromagnetic whereas austenite is not. Such a magnetic change could be detected at a dis-

*The authors thank P. M. Bournazos and Mrs. J. M. Webb, Foxboro Co., for their cooperation in the building of the earlier model signallers; W. K. Halstead and E. W. Jervis, Jr., W. S. MacDonald Co., for design and construction of the later models; F. L. Carr, R. Miles, and B. Bovarnick for their cooperation in testing these instruments.

Electronic Crack Indicator

tance without having to touch the part or disturb the quench.

After preliminary work, an instrument was designed and constructed for pilot-plant use in an 1850-gal. quench tank measuring 5 ft. in diameter and 12½ ft. deep, made of ¼-in. steel plate. A plywood coil form 3½ ft. inside diameter is placed within the quench tank (Fig. 1). To permit circulation of the quenching water around and within the coil form, the form is rigidly braced and supported by 14-in. legs resting on the bottom of the quench tank. On this form are wound several coils. By choosing one of these as a "driver" and another as a "secondary" or pickup coil, it is possible to obtain the signal from any one of three vertical zones in the quench tank (or all zones combined). Our equipment is for work of various shapes and sizes up to 10 ft. long.

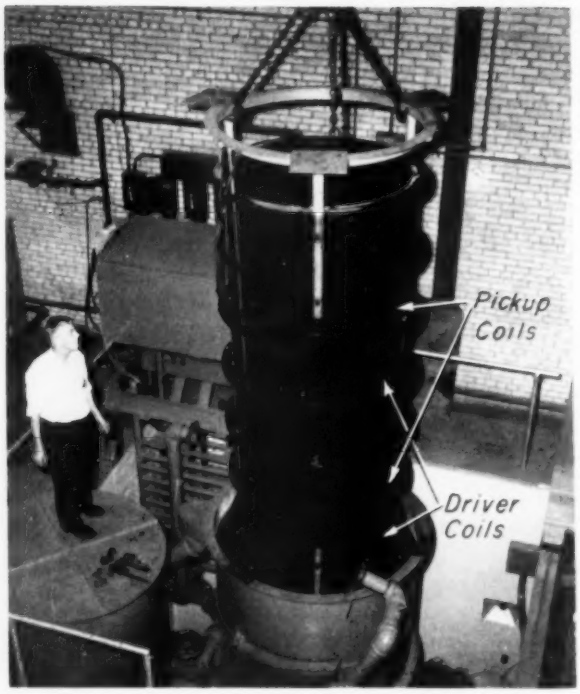


Fig. 1—Sensing Coil for Quench Signaller, Showing Its Size and the Location of Driver and Pickup Coils. Directly below it is the quench tank in which it is contained

DESIGN OF QUENCH SIGNALLER

During quenching, the steel part (or that portion of it from which the signal is desired) is held in the energized zone being used (Fig. 2). When martensite forms, the associated increase in magnetic permeability increases the magnetic flux linkage between the coils and so changes the voltage induced in the pickup coil. This voltage is amplified, rectified, and used to operate a relay which lights a lamp and rings a bell.

A low-frequency alternating current of 0.75 cycle per sec. is used in the driver coil so as to reduce magnetic skin effect. Thus martensite can be detected to an adequate depth below the surface of the part. The 0.75-cycle current is generated by running direct current through a motor-driven commutator and associated resistance network.★

To insure that the signaller had sufficient sensitivity and stability, tests were made with a pair of steel cylinders 8 in. diameter and 18 in. long, one with a ½-in. and the other a ¼-in. wall. The apparatus was set so it would signal with the thick-walled cylinder but not with the thin one. Experiment showed that the signaller correctly distinguished the cylinders, without resetting, despite change of water temperature from 75 to 85 F., and changes in the position of the part amounting to 18 in. horizontally (9 in. to right or left of center) and 6 in. vertically. Other tests showed that operation was not significantly affected by horizontal position changes of 22 in., and that magnetic material affected the signaller through an intervening ¾-in. thickness of steel. This means that the signal is not primarily indicative of the condition of the steel at the extreme outer layer, which would be greatly affected by oxidation and scaling.

PILOT PLANT TESTS

Finally, tests were carried out to determine reproducibility of signaller operation under conditions simulating normal heat treating practice. A cylinder of 0.30% C, 2.5% Ni, 0.9% Cr, 0.4% Mo steel, measuring 8 ft. x 7¼ in. outside and 3¼ in. inside diameter, was quenched repeatedly from 1650° F. and withdrawn from the water when the signaller bell would ring. In six quenches, despite changes in water flow from 200 to 1800 gal. per min., as shown in

★Electronic details of an earlier model signaller have been described by W. K. Halsted and L. D. Jaffe in *Electronics*, Vol. 23, November 1950, p. 109. It differed from the present model chiefly in operating at 60 cycles per sec. instead of 0.75, so that its use was limited to small pieces. Likewise, the coil arrangement necessitated that the steel part be held in the top half of the quench tank.

Table I, the temperature at which the cylinder equalized upon withdrawal from the water was constant within ±9 F., as indicated by thermocouples located within the wall of the part. (The calculated M_s temperature for this composition is 707 F.) The time in the water varied from 77 to 90 sec. This is a good example of the fact that *time* in the quench is not a very good control for fairly heavy pieces of steel.

In another series of three quenches, noted in Table II, the hot part was held in air for times of from 25 to 259 sec. prior to quenching, so that the temperature of the part at the start of the quench varied from 1650 to 1450 F. The time in the water varied from 73 to 84 sec., but the temperature of the cylinder after withdrawal was again constant within the limit mentioned.

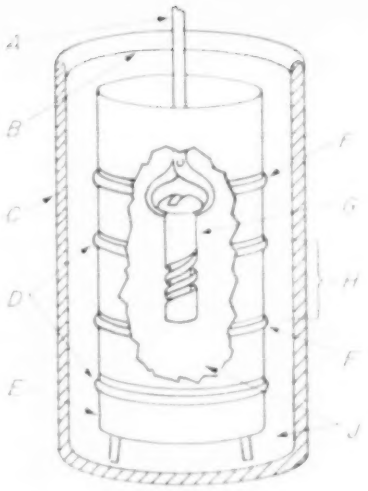


Fig. 2—Sketch Showing Location of Typical Part During Quenching
A—Tongs
B—Level of quench
C—Quench tank
D—Driver coils
E—Plywood coil form (with aluminum rub rails inside and out)
F—Pickup coils
G—Part being quenched
H—Middle zone used for this part
I—Water in quench tank

Shop Instrument

This experimental instrument is now considered satisfactory for shop evaluation. Identical electronic units could be made for installation in many shops, but the coil would have to be tailored to fit the quench tank. Although good quenching practice calls for a large tank—large in comparison to the part quenched—the heat treater would probably prefer to have the coil *outside* the tank. This might be done in future designs.

As compared to a clock, a quench signaller should eliminate errors caused by variations in steel composition, fluctuations in temperature, agitation, and composition of the bath and variations in furnace temperature and time of transfer to quench, as well as variations in thickness and character of oxide scale.

Table I—Tests With Variable Water Flow

Quench	Water Flow (Gal./Min.)	Delay*	Time in Quench, Sec.		Equalization Temperature†		
			To Signal	To Removal	No. 1	No. 2	No. 3
No. 1	850	28	76	86	754	711	721
2	1800	37	80	88	752	720	720
3	200	30	80	88	752	703	712
4	200	25	81	90	752	703	—
5	850	30	70	77	763	709	—
6	1800	25	78	85	757	702	—

* Time (sec.) in air prior to quench.

† °F. recorded by thermocouples No. 1, 2 and 3, these being located in holes drilled longitudinally from top end of tube to midlength, with No. 1 and No. 2 at one side of the bore at one half and one third of the distance from bore to outside, respectively, and No. 3 on opposite side of bore and one third of the distance from bore to outside.

Table II—Tests With Variable Quenching Temperature

Quench	Water Flow (Gal./Min.)	Delay*	Temp. at Quench†	Time in Quench		Equalization Temp.†
				To Signal	To Removal	
No. 1	850	195	1510°F	77	84	730°F.
2	850	259	1450	66	73	738
3	850	25	1650	78	84	748

* Time (sec.) in air prior to quench.

† Thermocouple No. 1, located as described in footnote to Table I.

By E. N. CASE and A. M. WHITE ★
American Cyanamid Co.

ing extreme hygroscopic nature or high price, these were abandoned.

It was finally decided to study the addition of a fourth component to the old system consisting of sodium nitrate, potassium nitrate and sodium nitrite. A number of inorganic compounds were investigated but those which had any beneficial effect presented rather serious disadvantages for commercial operations. Water was ultimately investigated as an additive. Since—believe it or not—this quaternary system has a considerable degree of practical usefulness, our results are recorded here.

Water in Molten Salt Increases Quenching Power Lowers Operating Temperature

SEVERAL years ago, the problem of obtaining a molten bath which would operate satisfactorily at 275° F. or lower was presented to the laboratory of the company with which the authors are associated. At present the only low-temperature salt in common commercial use is a ternary mixture of sodium nitrate, potassium nitrate and sodium nitrite whose freezing point is variously stated at 285 to 290° F.† Examination of the literature disclosed a number of possibilities in other nitrate-nitrite systems such as those involving sodium, calcium and lithium nitrates or in certain chloride systems, but for one reason or another, including extreme hygroscopic nature or high price, these were abandoned.

It was finally decided to study the addition of a fourth component to the old system consisting of sodium nitrate, potassium nitrate and sodium nitrite. A number of inorganic compounds were investigated but those which had any beneficial effect presented rather serious disadvantages for commercial operations. Water was ultimately investigated as an additive. Since—believe it or not—this quaternary system has a considerable degree of practical usefulness, our results are recorded here.

In the experimental work, freezing and boiling points were determined on melts of approximately 800 g. in Pyrex glass beakers. The mixtures were melted over a bunsen burner and the temperature of the melt measured by an iron-constantan thermocouple which was standardized at the temperature of boiling water. A pencil-type unit, in which the iron portion of the thermocouple is also the protection tube, was employed because of its small size and rapid temperature response. A Speedomax instrument with a range of 0 to 300° C. (32 to 572° F.) recorded the temperatures.

Operating Ranges—The freezing point was indicated on each cooling curve by a rather abrupt change in its slope and a constant or nearly constant temperature region. Boiling points were determined visually. Frequent weighings were made to establish the actual amount of water in the mixture on which the observations were made, and to replace any

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†For example, in "Tool Steels" by Gill *et al.*, p. 211 of the 1944 edition, and in "Metals Handbook," p. 284 of the 1948 edition.

losses at the boiling temperature. The data obtained are shown in Fig. 1.

It may be noted that the spread between the freezing point and boiling point is greatest for low concentrations of water but it decreases to a minimum of about 110° F. when the concentration of water is about 7%. Thus, it is apparent that water can be added to the nitrate-nitrite ternary mixture to make a quaternary system of lower freezing point, yet with a high enough boiling point to provide a useful operating range. We were surprised to find that the freezing point of our ternary mixture of salt was 291° F. (before water was added) whereas the freezing point in the standard text on tool-steel reports it to be 285° F. Our salt contained 0.14% of moisture originally and the lower freezing point noted in the literature would result from a higher water content, but one which is still below the maximum limit of 1% allowed by commercial specifications for similar mixtures such as General Motors specification GM-1845-M. Because of the hygroscopicity of the individual salts, particularly the sodium nitrite, water is readily absorbed by the crystalline salts under normal conditions. The value of 294° F. shown in our curve is obtained by extrapolation to 0% moisture, and appears to be in substantial agreement with the data of other investigators who used dry salts.

Benefits of the salt system containing water can be applied to several practical operations. The most obvious is a tempering bath for temperatures below 300° F. It has been found in actual practice that, once the bath has been prepared with the proper amount of water, it maintains its original composition for long periods of time at temperatures below the boiling point of the mixture. In the tempering operation, the steel which enters the bath is ordinarily cooler than the bath. Thus, there is no chance of localized boiling to drive off any of the water and the composition remains constant.

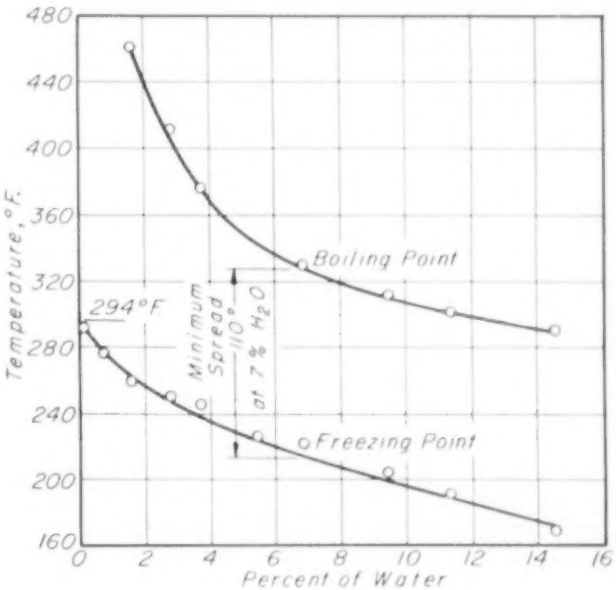
Use for Tempering and Hot Quenching

Quenching Power—A second and perhaps even more useful application is for martempering or other hot quenching operations. A. M. White has already shown in *Metal Progress* for December 1949, p. 819, that the cooling rates in salt baths at 350° F. are comparable to or even higher than those obtained under optimum conditions in oil quenching. If the temperature of the salt bath is lowered (by the addition of water) or even if a water-containing bath is used at an equal temperature, then considerably faster rates are obtained than with oil. This was observed in 1931 by the British investigator Bernard Thomas, who warned (in an article in *Heat Treating and Forging*) against the presence of water in quenching salts because of the danger of causing quench cracks. This point of view is understandable when it is considered that the concept of hardenability was not fully understood in 1931. The same investigator, in an article in *Metallurgia* in May 1947, p. 28, suggested that the greater quenching power of a salt bath caused by moisture might be used to harden parts which do not have sufficient hardenability to harden otherwise. The effect of water on the quenching power of low-temperature molten salts has also been patented in connection with a heat treatment of glass.

The quenching power of the salt may be altered to provide the required degree of hardening for a specific type and size of steel by controlling the amount of water in it. This applies the principles of hardenability, but in this instance the variations that are considered are in the composition of the quenchant rather than in the alloy content of the steel. In actual practice, parts of too-low hardenability have been salvaged in this manner.

It will be noted on the graph that the boiling point decreases rather rapidly as the amount

Fig. 1—Effect of Water on Freezing Point and Boiling Point of Ternary Mixture of Potassium Nitrate, Sodium Nitrite and Sodium Nitrate



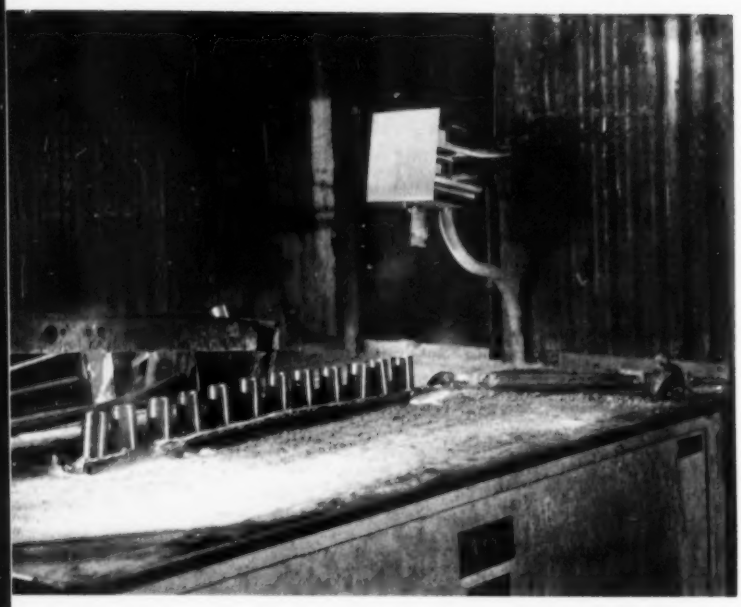


Fig. 2—Heating Rocket Motor Bodies in Salt Bath Furnace for Forging. Courtesy Ajax Electric Co., Inc.

of water is increased. While this is not of great consequence if the bath is to be used for tempering, it is a factor which should be taken into consideration when the bath is used for quenching. If hot metal is quenched into a molten salt mixture which contains water, the boiling point of the mixture will be exceeded momentarily where it comes in contact with the hot metal. If the mixture is already close to its boiling point, this tendency for boiling and rather rapid vaporization is increased. The effect is similar, although to a lesser degree, to that which is observed when hot steel is quenched into warm or hot water. While rapid agitation will serve to decrease the amount of vaporization, it is a good practice to quench into a mixture which is near its freezing point rather than close to its boiling point.

Maintaining the Composition—The fact that the water evaporates at high temperatures can be put to good use inasmuch as a bath which has absorbed water can be restored to its correct condition by raising its temperature to or close to the boiling point. In order to determine the amount of water present at any time, it is only necessary to measure the freezing point (or boiling point) of the bath and refer to the graph. This need not be done on the entire melt inasmuch as a small sample may be dipped out of the pot and the freezing point determined by a thermometer. More water may then be added, if required. If there is already too much, the excess may be evaporated or more of the water-free salt mixture added. In commercial quenching practice, water may be added from time to time as necessary to maintain the required quenching power of the bath; no other measure of the amount of water is required.

Safety First—Some caution must be exercised when water is added to a molten salt bath. As many know to their sorrow, localized boiling and violent spattering are likely to occur when water is introduced into a molten salt bath at high temperatures. Additions to the nitrate-nitrite bath should be made below 350° F., slowly, while the bath is being well stirred. The importance of this precaution was indicated by small-scale laboratory tests and has been borne out in larger installations. Even at 350° F. some spattering will occur, but the intensity of the reaction increases greatly with temperature.

The importance of caution cannot be stressed too greatly. The necessity to make water additions at *low* temperature makes it undesirable to apply the technique to molten mixtures which contain only nitrates and, therefore, have significantly higher melting points. Indications are, however, that the effect on such higher melting mixtures is only slight.

Many heat treaters will instinctively shy away from the idea that water and hot salt will mix. Their fears can be quieted after a demonstration that low-temperature tempering salt *on the cool* side can safely absorb considerable amounts of water. Also they may be reminded that such commercial salts, supposedly in dry condition, are prone to absorb moisture from the atmosphere, and may contain up to 1% water without contravening the usual commercial specifications for salt for tempering purposes.

The salient features of the above discussion may be summed up in a few sentences.

1. Molten baths which may be operated at temperatures considerably below 300° F. are obtained simply and conveniently by adding water to a mixture of potassium nitrate, sodium nitrite and sodium nitrate.

2. Such a mixture is useful for low-temperature tempering and as a quenching bath of high quenching power.

3. These advantages are obtained at virtually no additional expense.

4. Caution must be exercised when preparing such baths.

5. The normal characteristics of the bath can be restored when desired.



Fig. 1



Fig. 2

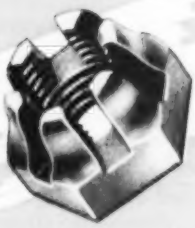


Fig. 3



Fig. 4



Fig. 5



Fig. 6

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Manufacture and Characteristics of High-Temperature Bolts

IN THE DESIGN of high-temperature bolting, environmental conditions require that such factors as oxidation, corrosion, creep, fatigue, notch sensitivity, and stress-rupture must be taken into account, in addition to elevated temperatures. The time-temperature-stress relationship is the most important and difficult consideration because elevated temperatures and corrosive environments complicate the usual design problem of providing adequate strength in the component.

Bolts for use at elevated temperatures in gas and steam turbines, turbo-jets, and in atomic power plants are highly specialized, both in engineering and metallurgy. Designs are not standardized, tolerances, of necessity, are extremely close, and mechanical properties are near the limit of ability of the machines to

Fig. 1—Tube Nut of Type 303 Stainless Steel With Slots Spaced Within ½° of True Angular Position and the Holes Spaced Within 2° of True Angular Position and 45° to the Slots. The diameters must be concentric within 0.004 full indicator reading of the thread pitch diameter. Fig. 2—Hexagon Head Dog Point Drilled Machine Bolt of Type 321 Stainless Steel. Dog pointing is done in a cold header. The drilled hole and the dog point must be held to close tolerances. After cold heading, the bolt is roll threaded. Fig. 3—Hexagon Castellated Nut of Discaloy Is Difficult to Manufacture From This Alloy, Yet It Must Be Held to Close Tolerances. Fig. 4—Trunnion, Measuring ⅞x⅞ In., of Type 410 Stainless Steel Presented Difficulties in Cold Heading Due to the Extremely Large Head and the High Tensile Strength Required. Originally machined from bar stock, the cold headed trunnion has reduced production costs and saved strategic metal. Fig. 5—Drilled Stud, ⅞ x 2⅞ In., of Refractaloy Is Difficult to Handle From a Machinability Standpoint. After roll threading, each stud is X-ray inspected for interior fractures. Fig. 6—Special Bolt, ¾-20x3 In., of A-286. The alloy of which it is made is difficult to work and the double head offers unusual manufacturing problems

Margin of Safety for Bolts

fabricate and forge many of the metals used.

An ample margin of safety must be provided in the design to prevent the disastrous results that might be caused by bolt fractures during operation of the equipment. Failure of bolts normally occurs when a specified set or elongation has taken place. This elongation results not only when the initial tightening torque is applied, which causes yielding of the material of which the bolt is made, but also over an extended period of time due to creep which is accelerated at elevated temperatures.

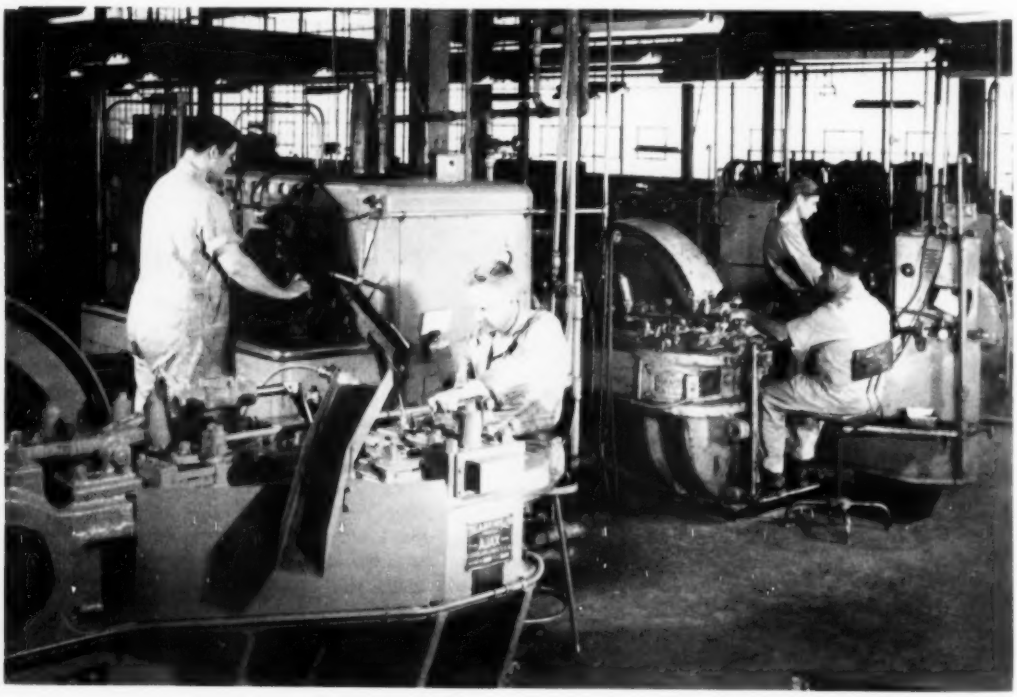
Resistance to corrosion and oxidation is, of course, essential in high-temperature bolting, but the combination of alloying elements to resist corrosion and oxidation must be such that there will be no sacrifice of strength. As a matter of fact, the common alloying elements, such as, tungsten, molybdenum, cobalt, and chromium, not only give an increase in resistance to oxidation and corrosion, but also increase the strength of the metal.

After metallurgists have developed high-temperature alloys to meet the demands that will be placed upon the metal, it is then necessary for them to develop methods to fabricate the alloy. Each added element that increases the hot strength of the alloy imposes increasing difficulties in forging and machining. When satisfactory fabricating techniques have been worked out for a particular alloy, it is then necessary that these techniques be applied in mass production.

Basically, there are two methods of producing bolts: Bolt blanks may be machined from a hexagonal bar that has the same hexagon size as the head; the other method is to upset the bolt head from a round bar of approximately the same diameter as the shank. Threads may either be cut or rolled; however, for high-temperature applications, the rolled thread is required by most specifications. The desired properties of the bolting determine which fabricating operations should be used. Many times the required properties prohibit use of the simplest working method.

Most of the alloys used in high-temperature bolting are of the austenitic type—some have the added property of precipitation or age hardening. Austenitic alloys are used because of the stability of their crystalline structure at all useful working temperatures. However, these alloys require more power and reduced speed for forging or machining. Austenitic alloys

Fig. 7—Hot Forging Department Where Bolts Are Hot Headed. Induction heating gives accurate temperature control within narrow limits for maximum strength and proper grain structure



Nominal Mechanical Properties of Common High-Temperature Alloys

Alloy	Temperature, °F.			
	1000	1200	1400	1600
	Stress-Rupture for 10,000 Hr.			
Type 304	27,000	9,700	3,900	1,900
Type 347		11,000		
Type 316		18,200	6,900	1,800
Type 309		15,000	4,300	1,700
Type 310	23,000	12,000	4,000	2,000
Type 410	13,000			
Type 416	13,000			
Inconel "X"	100,000	56,000	22,000	2,000
16-25-6	72,000	28,000	12,000	
19-9DL		29,000		
	Stress for 0.10% Creep in 1000 Hr.			
Type 304	17,600	6,900	2,400	600
Type 347	19,600	8,200	2,500	1,000
Type 316	24,200	12,700	4,500	
Type 309	15,900	8,000	2,400	
Type 310	18,000	8,600	2,200	
Type 410	9,200	2,000		
Type 416	9,200	2,000		
Inconel "X"		63,000	30,000	9,000
Inconel	25,000	9,300	3,500	640
16-25-6		19,000	10,000	
Discaloy A-286	51,000	32,000		

harden appreciably when subjected to cold work, making them even more difficult to machine.

Machining bolts from a hexagonal bar is costly and, while it may be economically acceptable for very short runs, it is too expensive for large-scale production. There are two reasons for this: First, machining is slow and expensive; and second, the method is wasteful of material since a high percentage of it must be cut away. A quick comparison of the scrap produced by the two methods in the manufacture of a ½-28 x 1-in. hexagon head cap screw is given by these figures: Assuming the material in the finished bolt as 0% scrap, cold heading and trimming of the hexagon head produces 9.43% scrap, and machining from a hexagon bar produces 186.5% scrap. The alloys from which high-temperature bolting is made are invariably costly and—even more important—they are scarce. Any savings which can be realized by preventing waste of material are therefore doubly important. The Aero Division of the H. M. Harper Co. prefers to cold forge and hot upset bolts, since these methods mean a reduction in cost and an important saving in material.

There are three processes which can be satisfactorily used to upset the head of a high-temperature bolt—namely, cold upsetting, "hot-cold" working, and hot forging. In cold heading, the rod is fed into a cold header which upsets the head in a forming die. Normally two blows of the hammer are required, the first upsetting the material and the second finishing to size and shape. Hot forging is done at or above the recrystallization temperature. Induction heating is often used because it is rapid, and can be controlled within close limits as to temperature and the length of bar to be heated. "Hot-cold" working may be done on a hot forge machine or cold header. The material is heated to an elevated temperature that is somewhat *below* the recrystallization temperature of the alloy.

Three Methods of Upsetting

Operations that are performed hot require less power than equivalent deformation performed cold. With some alloys, hot working is the only method of upsetting without fracturing the metal in the process. Often in working high-temperature alloys, grain size must be controlled within narrow limits. The temperature for "hot-cold" working must be controlled within a few degrees for optimum forging properties without exceeding maximum allowable temperature.

For hot forging some of the alloys, the specifications allow forging temperature above the recrystallization temperature. Temperatures as high as 2200 and 2300° F. are not uncommon, but again the maximum temperature must be controlled within close limits. In many alloys, if the upper temperature is exceeded by as little as 25° F., incipient fusion may take place at the grain boundaries. Such change destroys the toughness of the metal and the bolt cannot meet specifications.

Cold heading of this class of alloys offers great difficulties. Their yield strength is high and cold working is rapid. Tools and dies must be made of hard, yet tough, shock-absorbing steels, and these tools must have high finishes. Consider a typical example: Before upsetting, the alloy may have a hardness number approximately one-third that of the tool. After the head has been upset, the hardness number of the bolt head will increase 100% and be two-thirds that of the tool, not uncommonly reaching Rockwell C-40 to 45.

The same conditions of high yield strength and rapid cold working add to the difficulties of roll threading. In high-temperature bolting, constant effort is made to increase the strength at elevated temperatures. Roll threading,

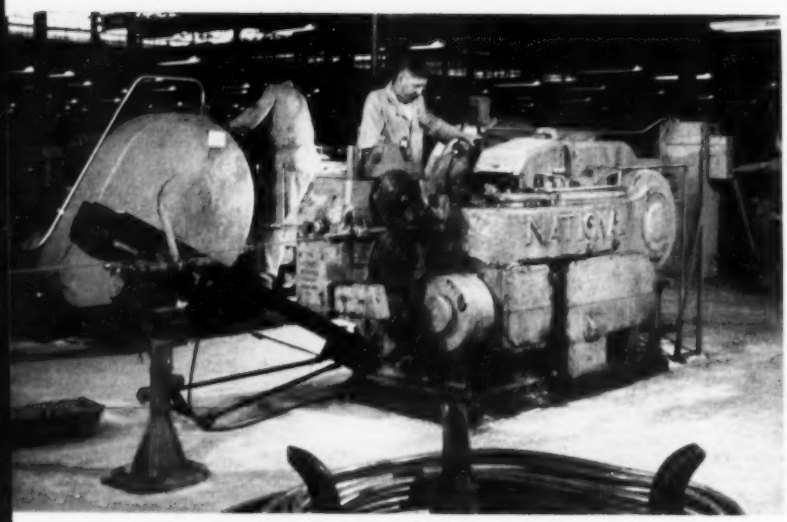


Fig. 8—One of the Many Cold Heading Machines in the H. M. Harper Plant. Cold heading of hard alloys gives a strong aircraft bolt with little waste of metal

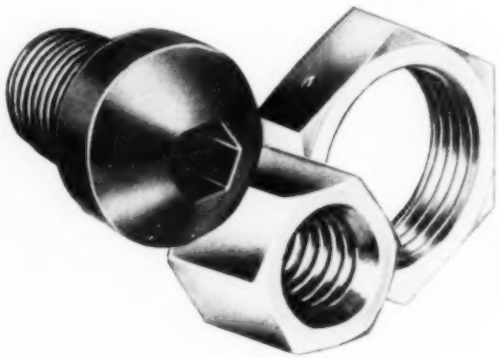
because of the cold working, increases the strength in the reduced section of the threads and gives the bolt a more uniform strength throughout its entire length. In roll threading, the notch effect of a sharp angle at the base of the thread has not been removed but is displaced by cold work, and the surface layers have high residual compressive stresses. The grain or fibers of the metal follow the contour of the threads. This condition adds to the tensile strength and fatigue characteristics of the metal in this area, which is extremely important in gas turbine applications. When threads are cut instead of rolled, the threads may also have a torn surface; this roughness increases the tendency to gall at elevated temperatures.

Proper heat treatment of the alloys used in high-temperature bolting is extremely important and may be a long operation, often lasting up to 45 hr. With both age hardenable alloys and alloys which are not age hardenable, heat treatments are selected to obtain optimum strength and stability. Age hardenable austenitic alloys require two heat treatments. The first of these is the solution heat treatment to recrystallize and refine the grain structure and to put soluble phases into solution. A secondary effect of this treatment is the softening of the metal, which increases the ease of forming or machining. The second heat treatment is aging at a temperature or combination of temperatures between 1200 and 1600° F., governed by the material and the ultimate temperature to which it will be subjected. It is customary to roll the threads when the metal is in the solution heat treated condition.

During aging, some constituent in the metal is precipitated in a very fine dispersion uniformly throughout the metal. These precipitates tend to "roughen" the slip planes along which plastic flow would occur when the metal is stressed, thus hardening and strengthening the metal. This type of hardness is retained at operating temperatures below the minimum aging temperature.

The nonhardenable austenitic alloys are either stress-relieved or annealed after cold working. This returns the metal to a stable condition. The stress-relief on the cold worked bolt reduces the internal or residual stresses without appreciable decrease in hardness. At the same time, the stress-relief increases the yield strength of the metal at room temperatures. In heat treating the high-temperature alloys, it must constantly be borne in mind that corrosion resistance must not be impaired or reduced.

High-temperature bolting must be a compromise between the properties of the metals available and the designer's requirements. A great deal of research has been done and is being done on the use of new or rare alloying metals in a combination of common metals to increase their strength at high temperatures. Of course, other factors, such as tensile and yield strength, creep, stress-rupture strength, notch sensitivity, oxidation and corrosion resistance must be taken into consideration. The producers who make fastenings of these newly developed high-temperature alloys are faced with the problem of developing the most economical methods of manufacturing that will at the same time reduce manufacturing time and save material. So far, cold heading has proved to be the most economical method for shop use.



By ROMAN OSADCHUK,
WILLIAM P. KOSTER
and JOHN F. KAHLES*

Recommended Techniques for Polishing Titanium for Metallographic Examination

DURING THE PAST year, a considerable amount of basic research on titanium and titanium-base alloys has been conducted at the University of Cincinnati. The alloys used in this program were Mallory-Sharon Titanium Corp.'s M.S.T. series 2Al-2Fe, 3Al-5Cr, 2.5Fe-2.5V and 5Fe-5V; Rem-Cru Titanium's RC-130-B; Ti-75-A, 100-A, 150-A.

Titanium and titanium alloys can, in general, be quite easily prepared for metallographic examination by either mechanical or electrolytic means. However, three general precautions cannot be overstressed. These are warnings against overheating during cutting and grinding, against mechanical straining during cutting, chucking, and mounting, and against smearing during polishing. A few materials present some particular difficulty. Certain alloys after heat treatment contain amounts of highly unstable beta phase which may be susceptible to structural alteration by mechanical straining and overheating; the beta is easily triggered by such influences and transforms to an alpha phase. Unalloyed titanium is also susceptible to mechanical straining and forms twin bands rather easily. Furthermore, the true structure of unalloyed titanium may be obscured because of smearing during the lapping or polishing operation. Nevertheless, with proper care, together with slight modifications of standard techniques, very satisfactory results will be obtained.

The basic procedure for the mechanical preparation of titanium found most satisfactory at the University of Cincinnati is outlined below. Included with each step is a brief discussion of possible variations. The suggestions of several other workers in the field are also included. This information should enable the metallographer to adjust the recommended procedure to suit his particular needs and facilities.

Sampling—*Cut the specimen under water with a silicon carbide cut-off wheel. Use normal speed and very light feed.* This method was found to be the fastest and most reliable of those tried. An aluminum oxide wheel will also produce a satisfactory cut on commercially pure titanium, but the wheel wear is excessive with many titanium alloys and "burning" or overheating becomes difficult to control. For large sections, a power hacksaw can generally be used successfully. Hand sawing is possible but is very tiresome and time consuming, and without any particular advantages.

Rough Grinding—*Grind on a wet belt using medium to firm pressure with a free-cutting silicon carbide belt of 60 to 80 grit. Flush the specimen generously with water during grinding. A medium belt speed is to be pre-*

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ferred. The purpose of this step is primarily to remove the layer of disturbed metal caused by the cut-off operation. Such a procedure is also recommended for the removal of the contaminated surface layer from heat treated materials. If a large surface is being prepared, it will be advisable to follow this step by grinding on a wet silicon carbide belt of 180 or 220-grit. This will facilitate subsequent fine grinding operations.

Mounting—*Titanium can readily be mounted in bakelite or lucite. Employ the minimum pressure necessary to obtain a densely compacted mount.* This procedure is entirely satisfactory except when judgment indicates that the temperature and mechanical strain encountered will influence the microstructure. Where such sensitivity is suspected, the sample should be mounted in a fusible material, mechanical clamp, or be polished in the unmounted condition. It may be desirable to regrind slightly on the wet belt grinder after this step in order to secure an even surface between mount and specimen.

Fine Grinding—*Grind successively by hand on 240, 400, and 600-grit silicon carbide papers (dry) using firm pressure and slow strokes. Follow by grinding for one minute on well-worn 600-grit silicon carbide paper using very light pressure.* With titanium alloys containing carbides and possibly other hard phases, silicon carbide papers seem necessary. With other alloys, emery papers (1/0 to 4/0) are quite satisfactory, although they are somewhat slower and less durable than the carbide papers. Wet grinding by hand offers no real advantage over dry grinding; hence the latter is to be preferred. The Titanium Metals Corp. suggests power grinding on silicon carbide belts of 240, 400, and 600-grit, using a cutting oil emulsion as a lubricant and coolant, followed by hand finishing on 600-grit silicon carbide paper. This method undoubtedly gives good results and would be suitable if a large number of specimens were to be prepared.

The most difficult step in polishing titanium is the removal of the scratches produced by the last grinding on the 600-grit paper. This step seems to be materially facilitated by grinding with very light pressure on a well-worn 600-grit paper, as mentioned previously.

Intermediate Polishing—*Polish for 3 min. on a medium-speed wheel covered with microcloth using No. 600 alundum abrasive suspended in a very dilute aqueous soap solution.* The time for this step must be limited since there is a tendency to cause pitting, but this method will be found satisfactory for most titanium alloys. In difficult situations, which will be encountered in preparing unalloyed and cold worked materials, a more specialized technique is warranted. The use of a diamond abrasive of 1 to 4 micron size in place of alundum, or polishing on a lead lap using a levigated 600-mesh silicon carbide abrasive (or American Optical Co. abrasive No. M303.5) is recommended for these. Paraffin wheels or cloths impregnated with paraffin have been suggested, but in this investigation they were found to be unsatisfactory for polishing titanium.

Specimens should be rotated on the wet polishing wheels to prevent directional flow and the formation of "comet tails". The polishing cloths should be damp but not wet. If the cloth is too wet, polishing will be slow and the specimen will become pitted. If too dry, excessive flow metal will form on the surface and pitting will again occur.

For the equivalent step, the Titanium Metals Corp. recommends the use of 600-mesh silicon carbide Crystolon Flour 600B on airplane wing cloth. The Sylvania Metallographic Laboratory employs 10 g. of Linde A alumina in 100 cc. water on a silk wheel for 1 min. Battelle Memorial Institute suggests a slurry of 15 g. of Linde B alumina and 30 cc. of 20% chromic acid in 200 cc. water to be used on a 1725-rpm. wheel covered with microcloth. (Surface passivation caused by the chromic acid is removed in a final polishing step which employs a paste of Linde B alumina on a medium-speed wheel covered with microcloth.)

Rem-Cru Titanium Inc. recommends the exclusive use of a lead lap for the intermediate polishing of titanium. The technique outlined by them for hand polishing with levigated 600-mesh silicon carbide on a lead lap is as follows:

1. The polishing suspension is prepared by placing a tablespoon of 600-mesh silicon carbide in ½ l. of water, stirring, allowing to settle 5 min., decanting, allowing the decanted liquid to settle 1 hr., pouring off the excess water from the decanted liquid and using the residue as the polishing suspension.

2. Lap is a piece of lead foil on plate glass.

3. Polish by placing several soap flakes or the equivalent amount of soap powder on the lap, adding several drops of polishing suspension, allowing the soap to soften, spreading the soap and suspension over the lap with the sample and removing previous scratches by back-and-forth strokes. Rinse excess grit from lap, redistribute soap film by applying a few drops

of carbon tetrachloride and spreading with the fingers. Do not add additional abrasive but polish again to remove previous scratches.

Final Polishing—*Polish for 6 to 8 min. on a medium-speed wheel covered with microcloth using 0.3 to 1.0-micron alumina suspended in a very dilute aqueous soap solution.* There is much less tendency for pitting in this operation and polishing time may be extended to 15 min. if necessary. When polishing unalloyed titanium, in which surface distortion is rather difficult to control, acidification of the abrasive suspension with a maximum concentration of 1% hydrofluoric acid will be found very helpful. The acid-abrasive ratio should be controlled so that the specimen remains bright during polishing.

The Titanium Metals Corp. recommends polishing for 3 min. with 0.3-micron alumina suspended in 5% aqueous solution of oxalic acid. The Sylvania Metallographic Laboratory recommends a mixture of 10 g. of Linde B alumina plus 15 drops each of hydrofluoric and nitric acids and 100 cc. water used on a Gamal cloth for approximately 1 min. Rem-Cru Titanium, Inc. is currently using dry gamma alumina (for example, Linde B-5125) on a microcloth lap moistened with 1% hydrofluoric acid. Some workers prefer a soft, long-napped cloth (such as produced by the Forstmann Woolen Mills) for this step of the polishing operation.

When an extremely fine surface is desired, such as for examination at very high magnification, one other step is recommended—namely, to etch the specimen lightly and polish for 1 to 3 min. with Gamal compound on a low-speed wheel covered with Gamal cloth. One or more repolishing and re-etching cycles will provide satisfactory results even with the most difficult specimens.

Etching—*Alternately etch and polish on the final polishing wheel.* This procedure is highly successful with most titanium alloys as well as unalloyed and cold worked materials. For the majority of microstructures, an etchant of 1% hydrofluoric and 2 to 3% nitric acid in water, applied by swabbing, gives excellent results. An immersion-type etchant, composed of three or four crystals of ferric nitrate, 4 cc. of hydrofluoric acid and 196 cc. of a saturated solution of oxalic acid is suggested by Battelle Memorial Institute. This etch was found to be very satisfactory.

Many alloys containing large amounts of beta stabilizers were most successfully etched with a mixture of equal parts of hydrofluoric acid, nitric acid, and glycerine. The reaction rate can be varied if necessary by adjusting the glycerine content, an increase in glycerine over a considerable range resulting in an increased speed of etching. For delineating grain boundaries and cracks, particularly in all-beta alloys, aqueous solutions containing up to 10% hydrofluoric with 50% nitric acid were found useful as etching reagents. In connection with hydrofluoric-nitric reagents, it was found that the etching time was controlled basically by the hydrofluoric concentration, and that the microstructure contrast was dependent upon the HF to HNO_3 ratio, a high ratio giving high contrast.

The formation of a brownish stained surface indicates an excess of hydrofluoric acid for the particular material being etched.

Re-Etching for Fine Surfaces

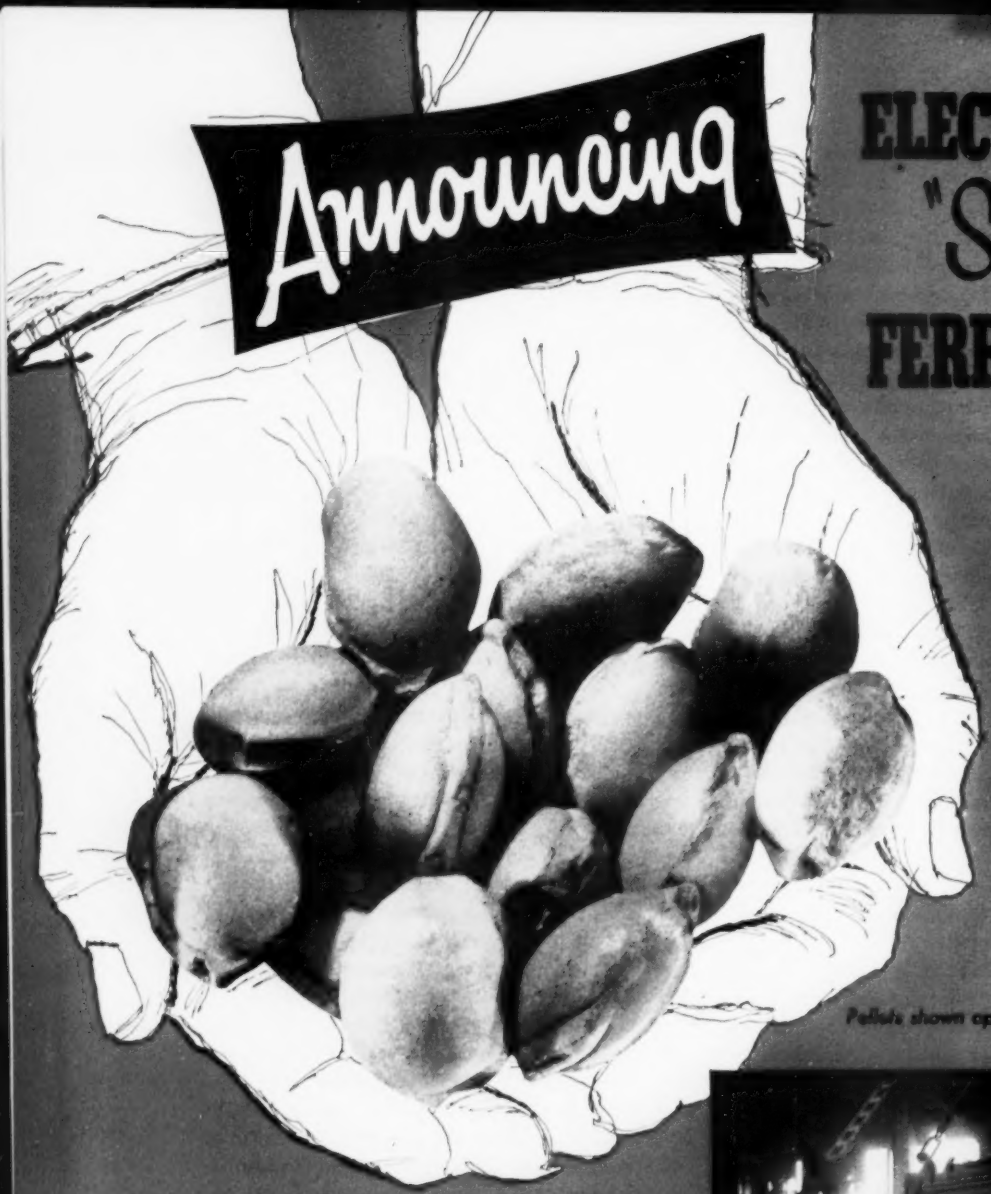
ELECTROLYTIC PREPARATION

The electrolytic preparation of titanium and titanium alloys for metallographic examination has been well developed. Generally speaking, this method is somewhat faster and requires much less skill than mechanical polishing. The first steps of the electrolytic and the mechanical methods are identical: sampling, rough grinding, and fine grinding. Mounting generally may be omitted; bakelite mounts should not be used with electrolytes containing perchloric acid! Intermediate and final polishing are replaced by a single electrolytic polishing operation.

At the University of Cincinnati, a Disa electropolishing unit is used for this purpose. Several electrolytes basically containing perchloric acid and alcohol have been evaluated. The best one found to date was suggested and is used by P. R. Mallory & Co. It is composed of 390 cc. methyl alcohol, 350 cc. ethylene glycol, 36 cc. 70% perchloric acid, and 24 cc. water. Perchloric acid presents an explosion hazard and is generally thought to be unsafe for this use. The perchlorate concentration in this electrolyte, however, is far below the level considered explosive. Furthermore, the large percentage of nonvolatile ethylene glycol in the solution precludes the possibility of a dangerous concentration level being reached by evaporation losses or by other causes.

Polishing conditions vary widely, depending upon the material being prepared; however, an emf. of 30 to 50 v. applied for 10 to 40 sec. is average. Unalloyed materials exhibited some pitting under these conditions and the pits could not be eliminated by time and potential variation. This condition was overcome by operating

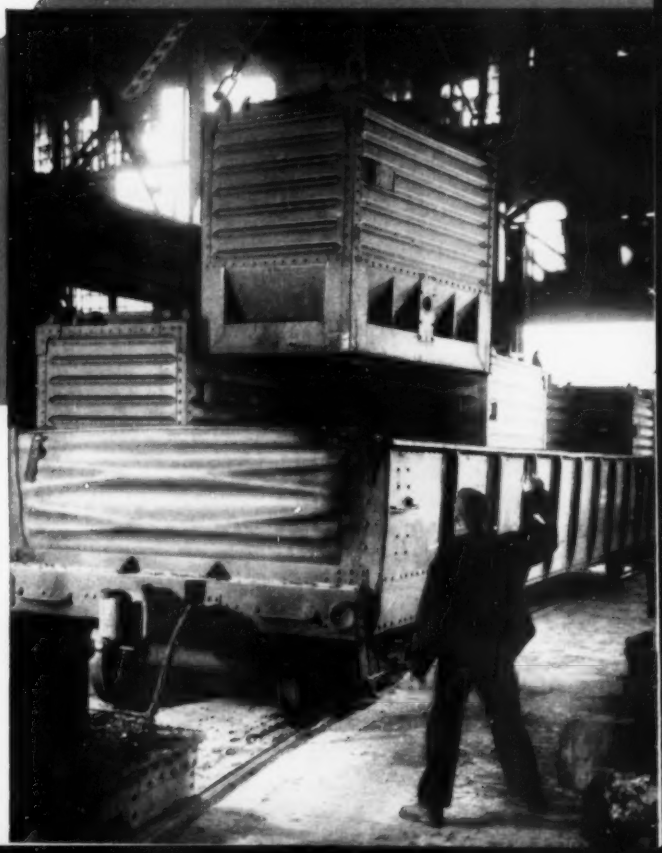
(Continued on p. 236)



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Pellets shown approximately 3/4 actual size.



1 EASY TO HANDLE

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The terms "Electromet" and "Simplex" are trademarks of Union Carbide and Carbon Corporation.

SIMPLEX ferrochrome is a new chromium alloy specially developed by Electro Metallurgical Company to simplify the production of stainless steel. The alloy is suitable for producing all grades of stainless steel and is specially adapted for the extra-low-carbon grades.

Outstanding advantages of SIMPLEX ferrochrome are its extremely low carbon content and surprisingly rapid solubility. These characteristics make it possible to reduce furnace time substantially, and to obtain a consistently high recovery of chromium together with a high metallic yield.

SIMPLEX ferrochrome is uniformly sized. It is produced in the form of pellets about the size and shape of a walnut. It contains about 65 per cent chromium and about 6 per cent silicon. The carbon specification is 0.025 per cent maximum. Maximum 0.010 per cent carbon can be furnished.

For additional information phone, wire, or write one of the ELECTROMET *offices. Ask for the* ELECTROMET *booklet entitled, "Melting Low-Carbon Stainless Steel." It shows the advantages that can be obtained in producing low-carbon stainless steel with* SIMPLEX *ferrochrome.*



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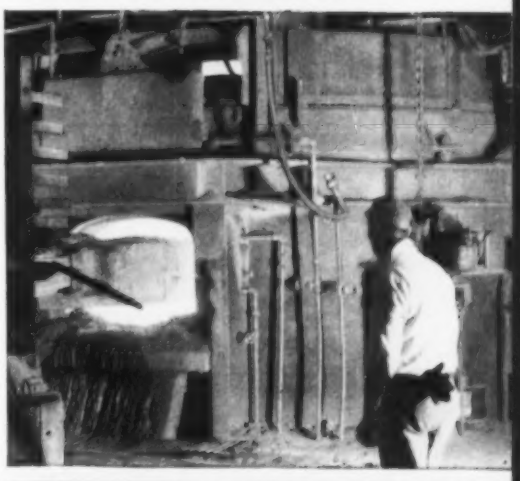
2 LOW CARBON CONTENT

Here is the new SIMPLEX ferrochrome ready for charging in the production of a heat of extra-low-carbon stainless steel. The carbon content of the pellets is so low that the addition of SIMPLEX ferrochrome will not increase the carbon content of the bath.



3 FAST SOLUBILITY

A charging machine dumps a loaded box of SIMPLEX ferrochrome in the bath. Because of the speedy solubility of the alloy in pellet form, as much as 15,000 lb. of SIMPLEX ferrochrome can be added to the furnace in one batch.



4 REDUCES FURNACE TIME

The alloy pellets dissolve in the bath more readily than does conventional lump ferrochrome. As much as 45,000 lb. of SIMPLEX pellets can be dissolved in slightly more than one hour. This means reduced furnace time.



5 HIGH METALLIC YIELD

The metallic yield averages about 90 per cent when SIMPLEX ferrochrome is used, since the alloy contains enough silicon to reduce metallic oxides in the slag back into the bath. Overall chromium recoveries of 90 to 95 per cent are obtained regularly.



Correspondence

Continuous Recovery Process for Acid and Metal From Pickling Solutions

DETROIT

In the pickling operation, a metal is soaked in an acid solution to remove an oxide coating from its surface. Acid is added to replace that used in the reaction until the concentration of metal salt is so large that the dissolution rate is slowed. The pickling solution is then discarded. It may be dumped or it may be treated either to recover metal or acid values from it or to produce a neutral, innocuous effluent.

Of the three acids commonly used in pickling steel—sulphuric, phosphoric and hydrochloric—sulphuric acid is probably the most widely used because it is the least expensive. Phosphoric acid is sometimes preferred because it gives a metal surface which is more suitable for subsequent working or coating operations. Hydrochloric acid dissolves the oxide scale more rapidly than sulphuric acid, but is more expensive. However, the continuous process for the recovery of metal and acid from hydrochloric solutions should offset this cost.

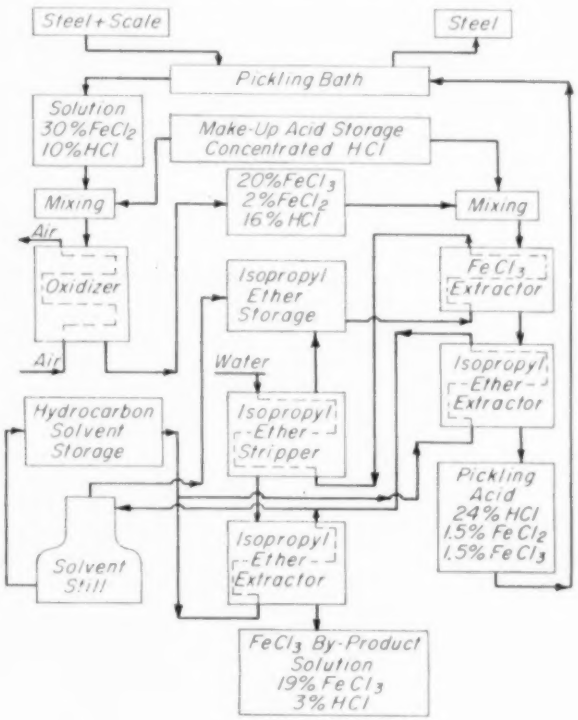
The cost of phosphoric acid pickling may be greatly reduced by the use of an ion exchange resin to remove iron from the waste pickle liquor with return of the iron-free acid to the pickling bath. Regeneration of the ion exchange resin, however, requires an amount of sulphuric acid somewhat more than equivalent to the iron removed and produces a sulphuric acid-iron sulphate effluent.

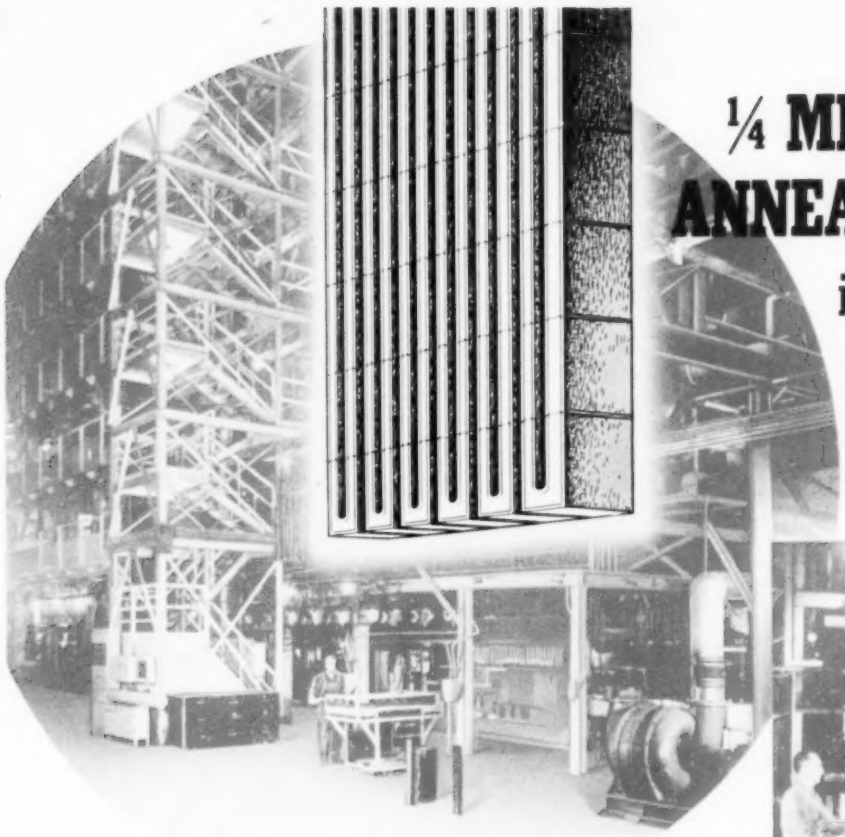
Ferric chloride can be removed from hydrochloric acid solution by extraction with isopropyl ether. However, the iron salt resulting from pickling steel with hydrochloric acid is ferrous chloride which is not extractable with isopropyl ether. Ferrous chloride dissolved in hydrochloric acid can be oxidized in air to ferric chloride, but unless this is done under proper conditions the rate of conversion is too slow to be practical. Appropriate conditions have been established for this reaction and it has been carried out as a continuous operation. The successful demonstration of this oxidation in air makes the process (shown in Fig. 1) worthy of consideration.

Recovery by this process is as follows: When the concentration of ferrous chloride in the pickling bath reaches 30%, liquor is drawn off and acid is added at such rates as to maintain this concentration. The liquor withdrawn is made up to 16% hydrogen chloride by addition of part of the make-up acid and is then oxidized continuously and countercurrently at around 150° F. in a steam-heated packed column by air introduced through a gas dispersion plate. With a ratio of 0.8 lb. of solution for each cubic foot of air, 85 to 90% of the ferrous chloride oxidizes to ferric chloride.

Extraction of ferric chloride with isopropyl ether is most effective at an acid concentration of around 25% and an iron concentration of 10 to 15% ferric chloride. The balance of the make-up acid is accordingly added to the oxidized solution prior to extraction with ether. A low acid concentration favors distribution in the aqueous phase in the isopropyl ether-ferric chloride-aqueous hydrochloric acid system. The ether is readily stripped by water of the ferric chloride which it carries out of the extractor. Extraction and stripping have been carried out in columns packed with glass helices. Any reasonably efficient extraction equipment should be satisfactory. *(Continued on p. 136)*

Fig. 1—Suggested Continuous Process for the Recovery of Metal and Acid From Hydrochloric Acid Pickling Solutions





¼ MILE of PSC ANNEALING DUCT in Steel Plant of

INLAND



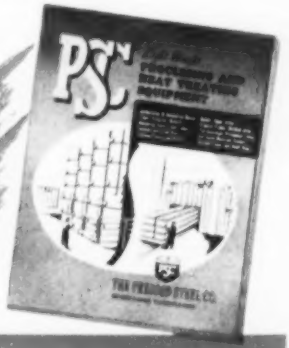
PSC 'Light-Weight' Alloy Equipment Solving Many Engineering Problems

This installation of PSC alloy duct for continuous annealing of strip steel is another example of how PSC "thin wall" construction is helping solve present-day engineering problems. Installed in the Indiana Harbor plant of Inland Steel Company, the system represents advanced designing in heat treating methods.

PSC "thin wall" construction effects hitherto impossible compactness and removability. It also introduces large economies in many types of construction, due to the savings in metal and to the lower fabricating and installation costs. Specializing in the precision fabrication of the weight-saving sheet alloys, PSC furnishes coils, ducts, flumes, manifolds, muffles and tubing for every heat and corrosion-resistant requirement; also tubes for radiant furnaces, and for furnace externals such as vent stacks. In any size and alloy.

Continuous strip steel annealing system at the Inland Steel Company plant, designed and built by Inland and Selas Corp. of America. PSC annealing ducts in black at top.

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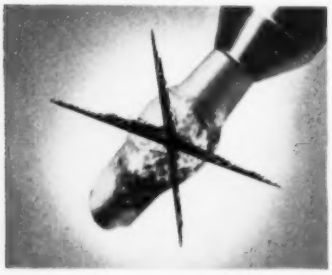
(Continued from p. 134)

Ferric chloride extraction and isopropyl ether stripping are carried out concurrently with recycle of ether, production of a pickling acid and production of ferric chloride solution. These last two streams contain a small amount of isopropyl ether which may be recovered by extraction with a hydrocarbon solvent such as *n*-heptane. Hydrocarbon and ether would be separated by distillation.

The process requires only an amount of acid over that required to convert the metallic scale to ferric chloride equal to the acid lost in the ferric chloride solution. This is about 335 lb. of hydrogen chloride for 10,000 lb. of pickle liquor. The isopropyl ether and hydrocarbon solvent are recycled and the loss of either should be very small in a properly designed plant.

The ferric chloride solution could be worked up for ferric chloride to be sold as such, but it is suggested that this solution be spray-dried to produce anhydrous ferric chloride for reduction to powdered iron and hydrogen chloride—the latter to be used in making hydrochloric acid for return to the pickling process.

RALPH H. MCCORMACK
Professor of Chemical Engineering
University of Detroit

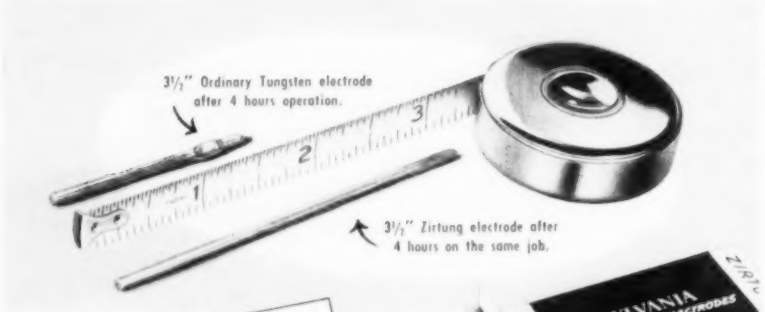


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Bird, Ghost, or Ghost Bird?



What appears to be a bird (or ghost—or is it ghost bird?) is an oddity resulting from the combination of cementite and manganese sulphide inclusions. This "thing" resting on martensitic needles was found in a specimen of cast steel that was etched with 3% picral solution and photographed at 1000×.

C. P. KENYON
Chief Metallographer
Sheffield Steel Corp.

Credit Omitted in July Data Sheet

PHILADELPHIA

Although the standard ferrite grain sizes published in your data sheet in the July 1953 issue of *Metal Progress* are from our Standard Methods E 89, no mention is made of this fact. Adequate acknowledgment to the source should have been made.

J. W. CAUM
Assistant Technical Secretary
American Society for
Testing Materials



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Personal Mention



Samuel L. Hoyt



Burns George

SAMUEL L. HOYT, member since 1921, has retired as technical advisor at Battelle Memorial Institute to engage in consulting practice. He is remaining as part-time consultant for Battelle and will divide his time between the operations in Columbus and those in Europe, devoting the remainder of his time to consultant work in the fields of research and development and metals technology. After teaching six years at the University of Minnesota, Dr. Hoyt resigned to become research metallurgist with the General Electric Co., where he helped develop Carboloy and introduce it into practice. From there he went to the A. O. Smith Corp., and since 1939 has been with Battelle, where he has been active in research and development, welding practice and metal fabrication and application. Dr. Hoyt is known to the profession through his lectures, technical papers and books, particularly as the author of "Metals Data." He takes an active part in organizations with which he is associated, such as American Society for Testing Materials, American Institute of Mining and Metallurgical Engineers, American Welding Society, and is a member of the Welding Research Council and the Committee on Ship Steel. He is also metallurgical representative on the Scientific Advisory Council of Picatinny Arsenal.

BURNS GEORGE, vice-president in charge of sales, Vanadium-Alloys Steel Co., Latrobe, Pa., has been named recipient of the 1953 McFarland Award for Achievement in Metallurgy by the Pennsylvania State College Chapter. Established in 1948 to honor outstanding metallurgical graduates of the Pennsylvania State College who have worthily distinguished themselves in some field of metallurgy, the award is named for Prof. David Ford McFarland, who served as head of the department of metallurgy at Penn State from 1920 to 1945. Those who are selected to receive the annual award are named on the basis of honorable attainment in any branch of the metallurgical profession in such a way as to bring credit to Dr. McFarland's alma mater. Burns George was born in Clarion, Pa., and graduated from Penn State in 1922 with a bachelor of science degree. His career in the steel industry began the same year when he joined the Illinois Steel Corp. at Gary, Ind. Following a period with Carnegie Steel Corp. at Homestead, Pa., he went to Vanadium-Alloys as metallurgical engineer. In 1943 he was elected to his present office. Mr. George is a member of the American Society of Tool Engineers, American Iron and Steel Institute, American Institute for Management and the Sales Executives of America.

Robert B. Gordon and **Zalman M. Shapiro** were among the ten engineers and scientists of the Westinghouse Electric Corp.'s atomic power division who received the Westinghouse Order of Merit—the highest honor awarded by the company— for their outstanding work in the design, development and construction of the nation's first atomic submarine engine. Dr. Gordon was awarded the Order of Merit "for his many important contributions in the field of high-temperature alloys; for the development of methods and processes for fabricating the unusual metals required for nuclear reactors; and for the construction of the reactor core for the first submarine atomic power plant". Dr. Shapiro received the honor "for his intense effort and success in the development of the basic methods and technology for the quantity production of high-purity zirconium for the first submarine atomic power plant".

George Parkin has been appointed director of research and development with Messrs. J. B. and S. Lees, Ltd., West Bromwich, England, and **Peter E. White** succeeds him as chief metallurgist with the same firm.

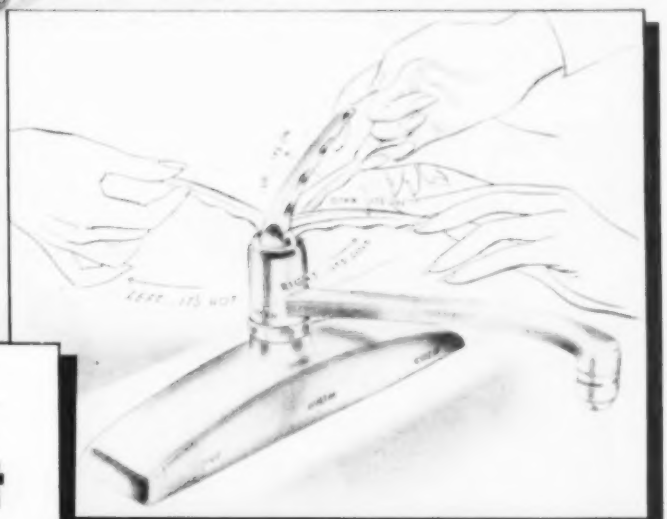
Charles E. Smeltzer, Jr., has accepted a position as metallurgist under the chemical and metallurgical program of General Electric Co. Mr. Smeltzer, a 1953 graduate of the School of Mineral Industries, Pennsylvania State College, is now on assignment with the lamp division of Cleveland Wire Works.

Robert M. Parke has been named manager of the materials and processes section of the metallurgy research department in the General Electric Research Laboratory at Schenectady. Mr. Parke will be in charge of a group of scientists engaged in pilot plant operations which form an essential step between new laboratory developments and their practical application.

George C. Towe, who recently received his doctorate in chemistry from the Engineering Research Institute, Ann Arbor, Mich., is now employed in the nuclear section at the scientific laboratory of Ford Motor Co., Dearborn, Mich.



Moen Single-Handle Faucet, made by Moen Valve Co., Division of Ravenna Metal Products Co., Seattle 5, Washington.



Sketch showing operation of Moen Faucet, which can be operated by one hand, giving water at the desired temperature at any rate of flow. You can change volume without changing temperature, or change temperature without changing volume, or select the desired temperature before turning on the water. Available in various styles and types.

Faucet maker finds **unit cost more important** than cost per pound

This Moen Faucet is unusual. First, its design represents a new idea in faucets so far as we know. If we are wrong, we will welcome the correction. But in any event, this modern faucet is selling like mad; people really want its convenience, its simple operation, its one-hand control. The second unusual thing about the faucet is that the spout is made of Admiralty Metal, supplied by Revere. This metal was chosen by Moen after consultation with the Revere Technical Advisory Service, which pointed out the qualities of Admiralty from the standpoints of bendability, and plating characteristics. Everything considered, the "more expensive" Admiralty turned out to be less expensive in the end, and more satisfactory both to the Moen Valve Co. and to its customers. The faucet also uses Revere Free-Cutting Brass Rod for interior machined parts, this again being chosen for workability and corrosion resistance. Service to Moen and to many other industries in the Mountain State area is of course provided by the Revere sales, technical and mill personnel on the Pacific Coast. Similar services are of course available from Revere everywhere in this great country. To obtain the Revere services, see the nearest sales office.

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Personals

William H. Dahlman, who has completed four years of metallurgical engineering at Case Institute of Technology, is now on a three-year foundry production training program at American Manganese Steel division of American Brake Shoe Co., Chicago.

Ralph G. Graham, who recently received the degree of M.Sc. from Queen's University, Kingston, Ont., is now employed in the metallurgical department, gas turbine engineering division, of A. V. Roe, Canada Ltd., Malton, Ont.

Arthur A. Gustafson has been appointed district sales representative covering the states of Minnesota and Iowa for the American Silver Co., Flushing, N.Y.

Charles J. Meinhart has resigned as instructor in the engineering division of California State Polytechnic College to accept a position as research engineer with North American Aviation, Inglewood, Calif.

C. Douglas Gardner is now an inspection engineer with National Petro-Chemical Corp. in its new hydrocarbon recovery plant at Tuscola, Ill.

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Darwyn I. Brown has resigned as technical editor of **Iron Age** to join Mullins Mfg. Corp. as market development manager of the Koldflo Division, Salem, Ohio.

John R. Witt is now employed by the Caterpillar Tractor Co., Peoria, Ill., in their college graduate training course. Upon completing the general training, he will be transferred to the metallurgical department of the physical testing division.

Robert S. Burpo, Jr. has been detached from the New York Naval Shipyard, Brooklyn, N.Y., and is now attending U.S. Naval Postgraduate School at Monterey, Calif., studying nuclear engineering.

John A. Nelson, formerly a research engineer with the Boeing Airplane Co. at Wichita, Kans., is now an assistant project engineer with the Marley Co., Inc., Kansas City, Mo.

Ronald V. Dubbins, who graduated from Case Institute of Technology with a B.S. in metallurgical engineering, is now employed as production trainee with American Manganese Steel Division of American Brake Shoe Co. at the Denver plant.

H. C. Fiedler, who received a doctorate in science from Massachusetts Institute of Technology in June, is now employed as a research associate at the General Electric Research Laboratory, Schenectady, N.Y.

Max Huber, formerly superintendent of melting department at George Fischer, Ltd., Schaffhausen, Switzerland, is now chemist-metallurgist for Battelle Memorial Institute, International Division, Geneva, Switzerland.

Courtland F. Carrier, formerly with Western Brass Mills, a division of Olin Industries, is now chief sales engineer of Meier Brass and Copper Co., Detroit.

Frank R. Yurkoski, Jr. has accepted a position with the American Car and Foundry Co., Berwick, Pa., as metallurgist.

Carl A. Meyers, Jr., formerly with the Wierton Steel Co., is now a research engineer at the Atomic Energy Division of Sylvania Electric Products, Inc., Bayside, N.Y.

The PROTECTION of ALUMINUM



Drawing courtesy of Piasecki Helicopter Corporation, Morton, Pennsylvania

THE H-21 Piasecki Tandem Helicopter—the "Work Horse"—is ideally suited for rescue work in areas inaccessible by other means, and in all kinds of rough weather.

For durable paint adhesion and high corrosion-resistance aluminum parts of the "Work Horse" are Alodized. The "Alodine" protective coating chemical bonds paint, extends paint life, and protects unpainted aluminum.

Because of its economy, effectiveness, and ease of application, the Alodizing process is finding wide-spread use in the aircraft field and in other industries fabricating products of aluminum.

Alodized aluminum meets the requirements of Military Specification MIL-C-5541. Write or call for coating and process data on "Alodine".

"Alodine" Trade Mark Reg. U. S. Pat. Off.

"ALODINE" PROTECTS BOTH PAINTED AND UNPAINTED ALUMINUM

"Alodine" forms an amorphous non-metallic surface on aluminum which is thin, tough, durable, continuous with and a part of the basis metal. The "Alodine" film (or skin) anchors paint, prolongs paint life, and protects aluminum exposed unpainted to the atmosphere.

ALODIZING IS EASY AND EFFECTIVE

The Alodizing process is a chemical one and does not require electrolytic techniques or equipment. Alodizing is simple, fool-proof, low in cost, and requires a minimum of equipment. Essentially, the process consists of the following easily controlled operations or steps:

1. Cleaning the work.
2. Rinsing the cleaned aluminum surfaces.
3. Coating with "Alodine."
4. Rinsing with clean water.
5. Rinsing with warm "Deoxylyte" (acidulated rinse).
6. Drying.

AFTER TREATMENTS: Alodized aluminum provides an ideal bonding surface for paint, wax, adhesive, or other organic finishes. These should be applied in accordance with the manufacturer's directions. Unpainted or exposed areas will be protected by the tough, durable "Alodine" skin.

"ALODINE" MEETS SERVICE SPECIFICATIONS

"Alodine" applied by immersion or spray complies with the rigid performance requirements of both industrial and Government specifications. The following is a list of Service Specifications which "Alodine" meets.

MIL-C-5541	U.S. Navord O.S. 675
MIL-S-5002	16E4 (SHIPS)
AN-E-19	AN-C-170 (See MIL-C-5541)
AN-F-20	U.S.A. 72-53 (See AN-F-20)

CHEMICALS ACP PROCESSES

AMERICAN CHEMICAL PAINT COMPANY

General Offices:

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Detroit, Mich. ***Niles, Calif.*** ***Windsor, Ont.***

Personals

Burton C. Person, who graduated from the Harvard Graduate School of Business Administration in June, is now employed in the economics and planning division of the Bayway, N.J., refinery of Esso Standard Oil Co.

Raymond J. Zale, formerly a steel metallurgist at Firth Sterling, Inc., Pittsburgh, has been promoted to assistant to the sales manager.

John J. Murphy, Jr. is now a technical trainee at the Aluminum Co. of America in the Cressona, Pa., plant. After completing his training period, he will go into extrusion metallurgy.

James D. Nisbet has been appointed director of research and development for Universal-Cyclops Steel Corp., Bridgeville, Pa. Prior to this appointment, Mr. Nisbet was manager of the materials and process section of the General Electric Co. Research Laboratory at Schenectady.

I. Melville Stein has been elected president of Leeds & Northrup Co., Philadelphia. **George W. Tall, Jr.**, vice-president of the same firm, assumes the additional post of secretary.

John J. Stobie has been appointed sales engineer of the west coast plant of Apex Smelting Co. at Long Beach, Calif.

John F. Haller has been elected vice-president in charge of engineering of Allied Products Corp., Detroit. Mr. Haller, who was the founder and president of Michigan Powdered Metal Products Co., Inc., until it became an Allied Products Corp. subsidiary in 1951, will continue to direct the development work of the former company from his staff position as chief of Allied engineering and research.

Richard W. Meek, who graduated from the Missouri School of Mines and Metallurgy in June, has accepted a position as metallurgist with the Cameron Iron Works, Houston, Tex.

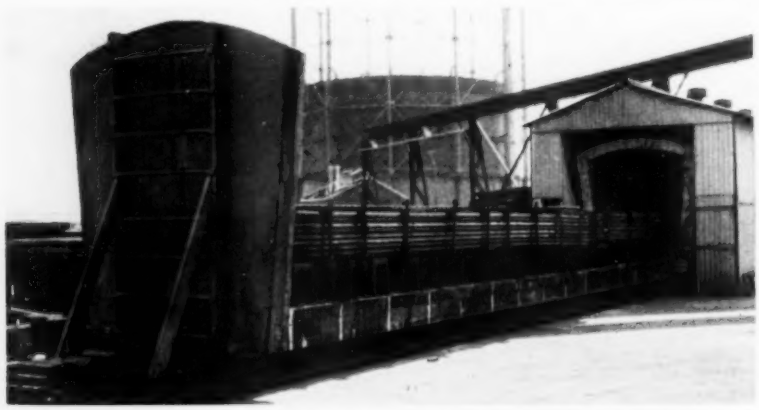
James E. Malek, a graduate of Marquette University, has accepted a position with General Motors Co., and is now supervisor trainee at the company's Saginaw (Mich.) malleable iron plant in the central foundry division.

Lee E. Tanner is now assistant metallurgist in the metals research division, nonferrous metallurgy section, of Armour Research Foundation of Illinois Institute of Technology, Chicago.

Michael J. Cusumano has returned to the Gary (Ind.) Steel Works, a division of United States Steel Corp., after a year's work with the physical metallurgy group at the U.S. Steel Research Laboratory in Kearney, N.J. His present duties are those of turn foreman in the metallurgical division.

G. Letendre, director of the department of mines and metallurgy at Laval University, Quebec, has recently been elected a vice-president of the Canadian Institute of Mining and Metallurgy.

W. D. Robertson is now associate professor in the department of metallurgy at Yale University.



This car bottom, stress relieving furnace was engineered by JET COMBUSTION in 1942 for the East Chicago Division of Combustion Engineering, Inc. After nearly six years of continuous service, JET remodeled it and elongated furnace and car to fifty feet. Since then it has continued in production, handling custom stress relieving jobs or production runs of long lengths of steel tubing. The furnace door was built on the car for economy and the entire furnace is housed in its own building to save plant floor space for more quickly completed operations.

JET has always designed heat treating furnaces with the customer's primary aim in mind—PRODUCTION FOR PROFITS. This means lower initial costs and constant high production.

JET engineered furnaces give you maximum diversity of use. More and more Jet customers are finding production more profitable by operating one sizeable Jet engineered furnace than several smaller ones, each limited in capacity and method of handling. Accurately controlled heat zoning plus a wide variety of work supports make it possible to use one Jet car bottom furnace for many types of work.

JET constructed furnaces mean more profits because you can count on maximum, round the clock, year-in-year-out production.

JET service means expert assistance when you need it for remodeling or adjustment to keep pace with your own ideas of production for profits.

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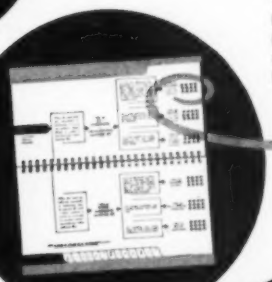
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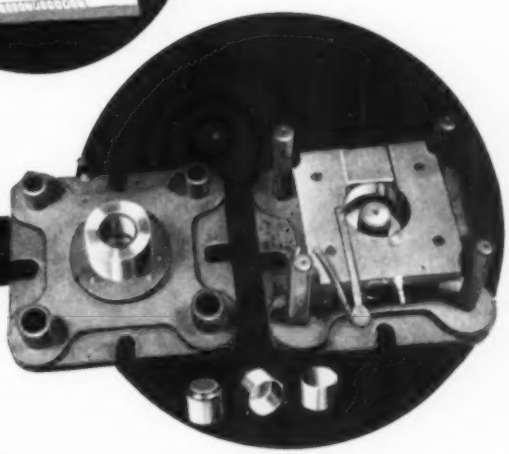
How ONE TOOLMAKER . . .



USED THIS GUIDE . . . . . —then use HAMPDEN (Oil-Wear) or No. 610 (Air-Wear)



TO HOLD DOWN UNIT COSTS . . .



AT which step in your tooling process would you welcome real help in reducing tool and die costs? Tool Steel Selection? Heat Treating?—or on-the-job "Trouble-Shooting"? Here's how you, like the maker of the Dies shown here, can start to reduce costs with a Method that helps you at *all 3* steps.

First, to simplify selection, use the handy Selector Section in the Carpenter Matched Tool Steel Manual. Quickly and surely, it enables you to put your finger on the proper steel for best results. Next, to further insure tool and die performance, use the Manual's complete heat treating instructions—they have been simplified beyond anything previously known. It's easy to get started—use the Carpenter Matched Set Method to help you "trouble-shoot" your present tool and die jobs.

For better, lower-cost tooling, put this practical, easy-to-use Method to work, now. Ask for the 189-page Carpenter Matched Tool Steel Manual—just see your Carpenter representative. The Carpenter Steel Company, 133 W. Bern Street, Reading, Pa.

Job:
Compound Blank and Draw Die for forming .031", ¼-hard brass Vent Valve Bodies at the rate of 103 per minute on a punch press.

Problem:
Unit costs were on the upswing because the old dies wore too rapidly, causing frequent and costly machine shutdowns for regrinding.

Solution:
Looking for a die steel with maximum wear resistance, the toolmaker referred to the Selector Section in the Carpenter Matched Tool Steel Manual, and quickly arrived at Carpenter *Hampden* (Oil-Wear).

Heat Treatment:
Simplified instructions in the Manual were followed.

Results:
2 hours of costly machine downtime were eliminated *each day*—production per grind *rose over 300%!* As a matter of interest, the toolmaker takes off approximately .0005" per stoning and gets about 100 grinds from the Blank and Draw Die.

IMMEDIATE DELIVERY FROM LOCAL STOCKS!

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Carpenter STEEL

Matched Tool and Die Steels

Export Department: The Carpenter Steel Co., Port Washington, N. Y.—"CARSTEELCO"

Mill-Branch Warehouses and Distributors in Principal Cities Throughout the U. S. A. and Canada

DO YOU KNOW WHAT HEAT TREATING COSTS
When You Do Your Own?

If you now do your own heat treating—or are contemplating the installation of a heat treating department—have you carefully considered all of the costs involved? Each of the following factors must be given careful consideration:

LABOR



Trained operators require years of experience, without them you cannot expect satisfactory heat treating. Can you afford men of this caliber for the amount of heat treating you require?

MAINTENANCE

Equipment must be kept in constant repair to prevent rapid deterioration. What does it cost you or what will it cost you?



SUPPLIES



Gas, electricity, chemicals—an endless variety of materials are needed continually. Are you wasting money due to insufficient work to keep all equipment going? Closing down and re-heating furnaces is an expensive waste.

TESTING EQUIPMENT

A constant check on heat treating operations and results is required to maintain quality and uniformity. Add this to the cost of your equipment along with skilled operators.



PLANT SPACE



Does your present department have enough space to work efficiently? If planning a new department, will it require an addition to your plant?

INSURANCE

What has the installation of a heat treating department done to your insurance rates? What can you expect if you are planning a new department?



EQUIPMENT



Can you economically install sufficient equipment to handle all of your requirements for hardening, annealing, carburizing, nitriding, etc., or can your present equipment handle all these operations with successful results? Is your capacity flexible enough to handle peak loads?

These are the major items to be figured into the cost of your own heat treating department—there are others which arise in special cases.

The problems listed here have been faced and overcome by commercial heat treaters. They know the answers because heat treating is their business—just as the manufacture of your products consists of solving numerous problems in your business.

There's a Heat Treating Specialist Near Your Plant

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Benedict-Miller, Inc.
Lyndhurst, New Jersey
California-Doran Heat Treating Co.
Los Angeles 23, California
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Bridgeport, Conn.
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Detroit 4, Michigan
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MTI
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METAL TREATING INSTITUTE

L-R Heat Treating Company
Newark, New Jersey
The Lakeside Steel Improvement Co.
Cleveland 14, Ohio
Metal Treating, Inc.
Milwaukee 4, Wisconsin
Metallurgical Control Labs.
Minneapolis 7, Minnesota
Metallurgical, Inc.
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Metlab Company
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It's Dice for the Best in Metal Testing Instruments



The METROSCOPE (Model MS-101) —measures thickness and detects defects in materials

Here is an extremely flexible and versatile test instrument which uses ultrasonic sound waves to measure thicknesses of metals and other sound conducting materials. It is particularly useful where measurements can only be made from one side of the material. Also detects internal defects or lack of bond between metals.

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"Non-destructive Testing and Measuring Instruments"

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ULTRASONICS

for rapid, accurate, non-destructive

THICKNESS MEASUREMENTS and FLAW DETECTION from one side

AUDIGAGE® Thickness Testers
Ranges: 0.020" to 4", and 0.060" to 12".

AUDIGAGE® Ultrasonic Micrometer
Direct-reading; Special ranges as required; Accuracy as high as ±0.25%.

CRYSTALS: Standard and special mountings; internal ground returns; high-temperature operation.

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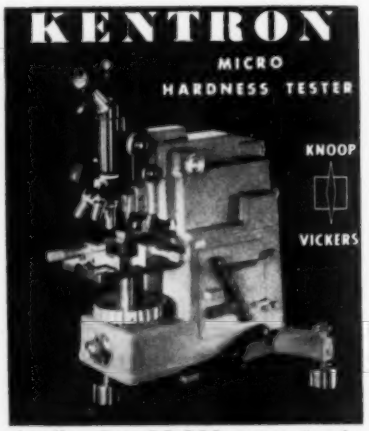
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KENTRON

MICRO HARDNESS TESTER



Applies 1 to 10,000 gram loads

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KENT CLIFF LABORATORIES
PEEKSKILL NEW YORK

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MERIAM MANOMETERS



U-TYPE • WELL TYPE • DUAL TUBE

FLOW METERS
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For measuring pressure, vacuum and differential pressure of liquids and gases. Also a complete line of accessories.

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◀ U-TYPE MANOMETER

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ALL TYPES OF LABORATORY FURNACES BY

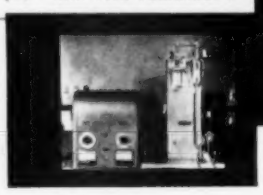
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NEW low differential flow meter

Employs diaphragm unit for measuring

1. air flow 2. gas flow
3. or air flow-gas flow ratio



Hays *Diaflow* Meter measurement in open hearth, soaking pit, billet, slab heating and annealing furnace indicates excessive amounts of air and/or gas . . . helps to prevent fuel and gas waste . . . serves as a guide in maintaining product quality.

Write for bulletin 52-1017-37

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Control Temperatures
More Closely
Reduce Cost — Save Time

Catalog No. 5 shows you how!
Get your free copy today!

- Thermocouples • Protection Tubes
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Low prices for top quality
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If you want to perform Tensile or Brinell testing operations quickly and simply—*contact*

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BE RIGHT IN ALL YOUR Abrasion Resistance Tests!



Model 140
TABER ABRASER

Simulates ACTUAL abrasion and wear conditions during test and gives ACCURATE numerical index for your report. Recognized the world over as the STANDARD for testing maximum wear resistance of all types of metals. Send for free booklet!

TABER STIFFNESS GAUGE

Determines both INITIAL and NORMAL stiffness of sheet and wire specimens and gives report from DIRECT READING.



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Inspection Demagnetizing or Sorting PROBLEMS?

SOLVED with . . .

"MAC" MULTI-METHOD EQUIPMENT Electronic Equipment for non-destructive production inspection of steel bars, wire rod, and tubing for mechanical faults, variations in composition and physical properties. Average inspection speed 120 ft. per minute.
Over 50 steel mills and fabricators are now using this equipment.

"MAC" DEMAGNETIZERS Electrical Equipment for rapid and efficient demagnetizing of steel bars and tubing. When used with "MAC" Multi-Method Equipment, inspection and demagnetizing can be done in a single operation.

"MAC" COMPARATORS Electronic Instruments for production sorting both ferrous and non-ferrous materials and parts for variation in composition and physical properties.

"MAC" MAGNETISM DETECTORS Inexpensive pocket meters for indicating residual magnetism in ferrous materials and parts.

FOR DETAILS WRITE: **MAGNETIC ANALYSIS CORPORATION**
42-44 Twelfth Street — Long Island City 1, N. Y.

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Alexander
SHEET METAL TESTER
For Erichsen Test

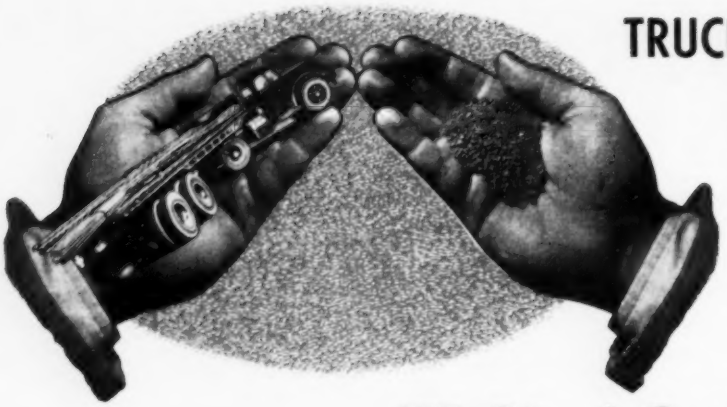


Determines workability of ferrous, non-ferrous and fine metal sheets and strips to point of fracture. Reading—accurate to 0.0004" . . .

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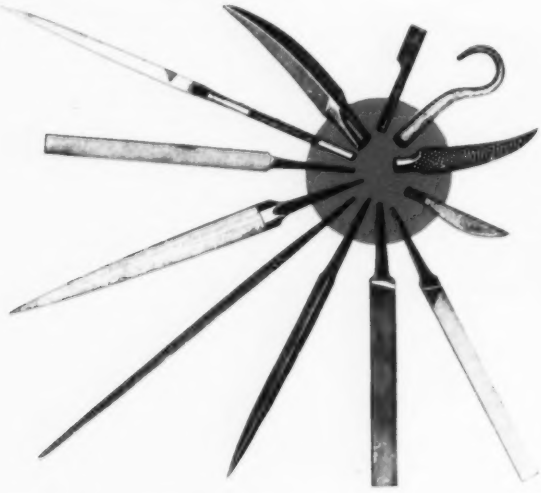
LAKESIDE sets the Pace in STEEL IMPROVEMENT

The Lakeside Steel Improvement Co. is the *largest* commercial steel treating plant in this area—offering the *widest range* of steel treating services. Recent expansions, coupled with the latest and most efficient equipment, have *greatly increased service speed*. Lakeside's *complete* metallurgical services insure that your steel will be treated to meet your *exact specifications*.

THE *Lakeside Steel Improvement Co.*

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ON ALL AMERICAN AND SWISS PATTERN FILES

NON CLOGGING • RUST RESISTANT • LONGER LASTING

Tiarco Corporation has appointed LR Heat Treating Sales Co. as distributor of Kromolloy Processed Files. *For further information, call or write to:*

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(for surface hardening stainless steels)

what it is . . what it does . . how it works . . how you can use it.

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A special "case history" section shows how nationally known manufacturers are specifying Malcomizing for the surface hardening of stainless steels.

Lindberg Steel Treating Co., covering industrial America from coast to coast, with plants in Rochester, Chicago, St. Louis and Los Angeles, is now licensed to Malcomize for its customers. For particulars call your nearest Lindberg plant.

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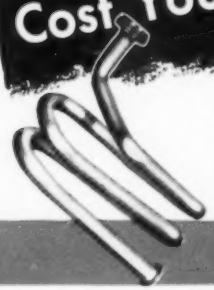
CHICAGO • LOS ANGELES • ROCHESTER • ST. LOUIS

LINDBERG STEEL TREATING CO.

LIST NO. 38 ON INFO-COUPON PAGE 158

How Much Does CORROSION Cost Your Plant?

Specify ILLIUM Consruction to Stop Corrosion Losses *PERMANENTLY*



This is Illium welded tubing. Easily bent and flared to exact tolerances, it retains a bright finish in service.

If your product or plant must handle sulfuric . . . nitric . . . phosphoric . . . mixed acids . . . or acid-salt solutions, you can profit by using Illium.

More than 30 years of use in critical processing operations have proved Illium unsurpassed in handling these highly corrosive acids—both liquids and gases—at virtually all concentrations and temperatures. In addition, it also serves to resist erosion and heat equally well.

Ideal for use in the drug, dairy, chemical and food industries because it lends itself so perfectly to sanitary construction. Other outstanding uses have been found in petroleum processing, ordnance work, and many marine applications.

Available in castings up to 575 lbs., Illium is easily machined and welded. Samples for testing and investigation will be sent upon request.

write for Bulletin 651 for Complete Data





THE ILLIUM CORPORATION, FREEPORT, ILLINOIS

Makers of Special Alloys and Quality Castings for Industry

LIST NO. 104 ON INFO-COUPON PAGE 158

Spotlighting

DETROIT'S BETTER

HEAT TREATER



OFFERING FACILITIES FOR:

1. **ALUMINUM**-*CAP. 500,000# PER MO.*
2. **MINUTE PARTS** *TO 2-TON DIES*
3. **BRIGHT HARDENING** *OF STAINLESS STEEL*

ALL TYPES OF HEAT TREATING CAN BE DONE BETTER BY

STANDARD STEEL TREATING CO.

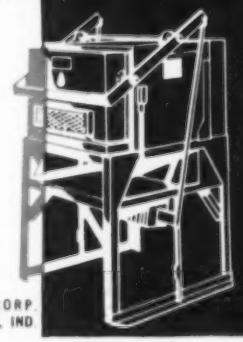
3467 LOVETT AVE. DETROIT 10, MICH.

Phone TAshmoo 5-0600

LIST NO. 49 ON INFO-COUPON PAGE 158

Expand Your Plant Potential

WITH *Cooley* ELECTRIC HEAT TREATING FURNACES



fast . . . inexpensive way to expand your plant facilities. Choose from 27 Models.

For Instance:



1. You save time and money by keeping heat treat jobs for small parts in plant.
2. It's easy to establish a new department at small cost in proportion to benefits which result.
3. Cooley heat treat furnaces pay for themselves through savings in time and subcontracting costs.
4. Heat treat operations are easily performed with Cooley designed furnaces.

Write now for Catalog giving complete details.

Cooley ELECTRIC MANUFACTURING CORP.

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LET'S PUT OUR HEADS TOGETHER---

TO GET THE HEAT TREATING CONTAINERS YOU WANT!



Tell Stanwood Engineers your particular problem—type of parts you are heat treating—furnace capacity—cycle, etc. With our broad experience and production facilities we can supply baskets, trays, fixtures, carburizing boxes, retorts or furnace parts to exactly meet your needs—economically too! Send for literature.



Representatives in Principal Cities

Stanwood Corporation

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LIST NO. 12 ON INFO-COUPON PAGE 158

Upton

. . . . OFFERS

the most advanced

Salt Bath **Furnaces**

FOR . . . .

BATCH TYPE WORK

o

CONVEYORIZED TYPE WORK

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ALUMINUM BRAZING

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o o
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UPTON ELECTRIC FURNACE CO.
16808 Hamilton Avenue
Detroit, Michigan
Phone: Diamond 1-2520

LIST NO. 20 ON INFO-COUPON PAGE 158

INDUSTRIAL FUEL BURNING EQUIPMENT..

Designed **FOR YOUR SPECIFIC REQUIREMENTS**

- Motor-Mix Burners
- Model DA Mixers
- Western Safety Valves
- Injector-Mix Burners
- Flame Retention Nozzles
- Accessories
- Inspirator-Mix Burners
- Blowers
- Multiport Burners
- Custom Built Equipment

Free descriptive literature on request

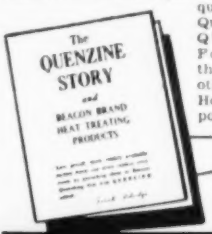
WESTERN PRODUCTS, Inc.
General Office, New Castle, Ind. — 549 W. Washington Blvd., Chicago 6, Ill.

LIST NO. 93 ON INFO-COUPON PAGE 158

FREE

the QUENZINE STORY

Low priced, more readily available carbon steels can often replace alloy steels when quenched in Beacon Quenching Oils with QUENZINE added. For information on this new additive and other Beacon Brand Heat Treating Compounds write to . . .



KELCO

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LIST NO. 29 ON INFO-COUPON PAGE 158

DEMPSEY FURNACES

GAS, OIL AND ELECTRIC
BATCH • CONTINUOUS

ATMOSPHERIC - RECIRCULATING - PUSHER — ROTARY HEARTH — CONVEYOR — RADIANT TUBE — POT CAR-BOTTOM - ALUMINUM REVERBS.

"Tailored by Dempsey"

DEMPSEY FURNACES

DEMPSEY INDUSTRIAL FURNACE CORP.
Springfield 1, Mass.

LIST NO. 79 ON INFO-COUPON PAGE 158

FAHRITE

HEAT AND CORROSION *Alloys*



Fahrite is used for:
Rails • Trays • Carburizing Boxes • Retorts • Chain Solution Pots • Rollers • Muffles • Radiant Tubes • many other products

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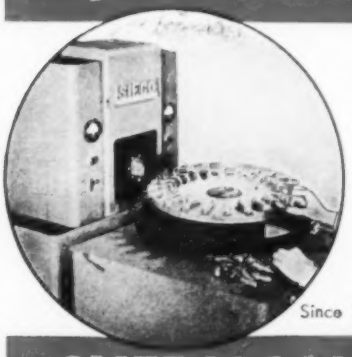
BIRMINGHAM, ALA.
CHICAGO, ILLINOIS
TOLEDO, OHIO
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NEW YORK, N. Y.
PHILADELPHIA, PA.
PITTSBURGH, PA.
ST. LOUIS, MISSOURI
SAN FRANCISCO, CALIF.
CINCINNATI, OHIO
TULSA, OKLAHOMA

THE OHIO STEEL FOUNDRY CO.
SPRINGFIELD, OHIO — Plants at Lima and Springfield, Ohio

ENGINEERS FOUNDERS FABRICATORS METALLURGISTS

LIST NO. 97 ON INFO-COUPON PAGE 158

INDUCTION HEATING EQUIPMENT



Megacycle Tube Type Machines

Soldering • Brazing • Bombarding
Annealing • Hardening

Sizes: Standard—2,4,10,25 KVA; Custom—to 100 KVA

Fast • Powerful • Reliable

Challenge Comparison—Value • Quality • Price • Design • Appearance

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Complete data, application photos, prices, delivery in New illustrated Catalog. Write on your company letterhead.

Since 1930... Pioneers in Megacycle Heating

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★ **Neutral Salts**

★ **Tempering Salts**

Faster more fluid baths!

Free washing!

Send for **FREE** Literature **TODAY!**

Swift
INDUSTRIAL CHEMICAL COMPANY
CANTON CONNECTICUT

CIRC-AIR

HEAT TREATING FURNACES

for Every Heat Treating Process

★

CONTROLLED ATMOSPHERES

★

DIRECT FIRED

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CIRC-AIR DRAW FURNACES

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CIRC-AIR NICARB
(CARBONITRIDING)

Specially Engineered for Your Particular Needs

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GAS • OIL • ELECTRIC

INDUSTRIAL HEATING EQUIPMENT COMPANY
8870 Fremont Pl. • Detroit 7, Mich.

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Natural Gas at 1# to 30#

for KILNS • HEAT TREATING ANNEALING • DRAWING SLOW COOLING

OUR BURNER ELIMINATES COMBUSTION ATMOSPHERE STRATIFICATION BY CONSTANT AGITATION OF THE ATMOSPHERE. CATALYST LINER INITIATES CONTINUOUS IGNITION WITH MORE COMBUSTION IN SHORTER PERIOD THAN POSSIBLE THRU NORMAL DEFLAGRATION.

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SWIFT BLACK!

. . . for Blackening

★ Single or Double Bath Process to meet Any Requirement

★ Faster, more Uniform Blackening

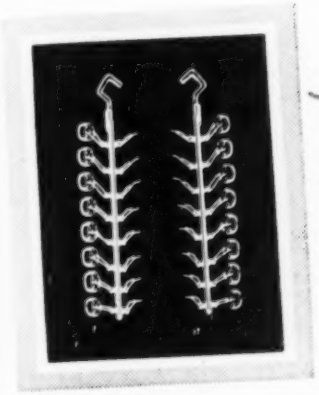
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★ Uniformity of Blackening Guarantees Economy

Send for **FREE** Literature on Swift **BLACK** and Cleaning Compounds **TODAY!**

Swift
INDUSTRIAL CHEMICAL COMPANY
CANTON CONNECTICUT

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Got a Problem?

NARACO HAS THE ANSWER!

With skill and ingenuity, NARACO engineers designed this fuse rack to answer the difficult problem of perfectly plating nozzles and ventricles. Need help? Call your NARACO office today.

NARACO

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IMPERIAL RACK CO. 1109 E. Stewart Ave. Flint, Michigan
INDUSTRIAL RACK CO. 3462 San Fernando Rd. Los Angeles, Cal.

LIST NO. 14 ON INFO-COUPON PAGE 158

20th Century



the persuasive abrasive

Production curves take on a healthier look when you use 20th Century *Normalized shot, *the persuasive abrasive.* In daily use in foundries and metalworking plants everywhere, its high uniformity has proven it more efficient, more economical.

Try it in *your* plant!

THE CLEVELAND Metal Abrasive CO.

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Howell Works: Howell, Michigan

*One of the world's largest producers of quality shot, grit and powder — Hard Iron — Malleable (*Normalized) — Cut Wire — Cast Steel (Realsteel)*

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today's "wonder drug" for industry

NOW...the greatest cost-saving, labor-saving FINISHING DEVELOPMENT in a decade!

Make expensive time-consuming operations like filing, grinding, polishing, blasting, buffing a thing of the past with New Amazing SUPERSHEEN SPEED FINISHING.

It absolutely does away with costly hand deburring and other hand operations requiring the use of large quantities of expensive materials and costly skilled labor.

A single unit replaces from 2 to 12 men. Savings up to 95% on almost ALL types of parts with absolute uniformity, fewer rejects, finer finishes.

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Write for NEW FREE, 52-page Catalog

Tells the complete story with latest facts, figures and "before and after" photos.

DEPT. J-7

ALMCO Supersheen

AMERICA'S LARGEST MANUFACTURER OF ADVANCED BARREL FINISHING EQUIPMENT — MATERIALS AND COMPOUNDS

ALBERT LEA, MINNESOTA

LIST NO. 75 ON INFO-COUPON PAGE 158

Insist on CIRCO

Since 1923

METAL CLEANING EQUIPMENT

DEGREASING SOLVENTS

- VAPOR DEGREASERS
- METAL PARTS WASHERS
- STEAM CLEANERS

PER-SOLV (Perchlorethylene)
CIRCO-SOLV (Trichlorethylene)

Manufactured by
TOPPER EQUIPMENT COMPANY
Clark Township (Parkway) New Jersey

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PYROSIL

Electric Immersion Heaters



for METAL PICKLING & PLATING SOLUTIONS

Totally inert to all acids at any concentration except hydrofluoric

Sizes: 1000 to 10,000 Watts

PYROSIL, Inc.
CUYAHOGA FALLS, OHIO

LIST NO. 106 ON INFO-COUPON PAGE 158



Portable Agitators

Light weight, heavy duty models with swivel clamp. Available ¼ to 3 HP sizes in three styles with either adjustable or rigid shafts.

Ideal for Quench Tanks, Salt Baths, Plating Tanks and Waste Treatment.

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DANIELS UTILITY BATCH PLATER



New multiple DANIELS PLATING BARREL unit designed to handle small lots of work economically. Individual removable tanks allow plater wide range of plating, pickling, or cleaning applications.

Send for complete details on this and other plating equipment.

DANIELS

DANIELS PLATING BARREL & SUPPLY CO.
MANUFACTURERS and DISTRIBUTORS
Electroplating and Polishing Equipment and Supplies
129 Oliver Street, Newark 5, N. J. • Tel. MArket 3-7450

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HOW TO DO BRIGHT GOLD PLATING *without scratch brushing or buffing!*

GOLD
SILVER
RHODIUM

Write for complete details

Sel-Rex

BRIGHT GOLD PROCESS

FOR INDUSTRIAL and DECORATIVE USES

1. Exceptionally hard deposits — twice the hardness of conventional gold plating.
2. Operates at room temperature — requires absolute minimum control.
3. Excellent metal distribution and "throwing power."

SEL-REX PRECIOUS METALS, INC.
Dept. BB, 229 Main Street
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WELDCO FABRICATED MONEL PICKLING EQUIPMENT

• Hairpin Hooks • Sheet Crates
• Steam Jets • Chain
• Mechanical Bar, Tube and Coil Picklers

THE YOUNGSTOWN WELDING & ENGINEERING CO.
3728 OAKWOOD AVENUE • YOUNGSTOWN 9, OHIO

LIST NO. 94 ON INFO-COUPON PAGE 158

BASKETS for all industrial requirements

for de-greasing — pickling
anodizing — plating
materials handling
small-parts storage

of any size and shape — any ductile metal

by

WIRE PRODUCTS Jelliff SINCE - 1880

THE C. O. JELLIFF MFG. CORP.
28 Pequot Road
Southport, Conn.

LIST NO. 91 ON INFO-COUPON PAGE 158

Du-Lite

"Gives our tools Sales Appeal"



BARNABY MFG. CO. of Bridgeport, Conn., reports: "Our close proximity to salt water has given us problems in rust prevention for many years. We have experimented with many black oxide finishes but none has proven as successful, safe, and inexpensive as DU-LITE—our tools have better sales appeal—our volume has been on the increase ever since we started using this modern, progressive oxide finish."

Depend on Du-Lite, the metal-finishing specialists, for the most efficient and economical cleaners, black oxide finishes and phosphate coatings. Write for full details on:

Du-Lite Black Oxide for Steel.
3-0 Black Oxide for stainless steel and malleable iron.
SD Compound for removing occluded salts.
Phosteel and Phospray for phosphatizing steel, iron or zinc.
Du-Lite Non-Acid Black Oxide for copper and copper alloys.
Dynakleen for bright cleaning all metals.
Kwikseal and Proctoil water displacing oils.

Or send us samples of parts and we will process them for your approval.

DU-LITE CHEMICAL CORP.
MIDDLETOWN, CONN.
Send more information on Du-Lite..... ☐
Send information on metal finishing products... ☐
Have your representative call..... ☐

Name .....
Company .....
Address .....
City ..... Zone ..... State .....

Du-Lite
METAL FINISHING SPECIALISTS

LIST NO. 103 ON INFO-COUPON PAGE 158

You can cut Cleaning and Peening costs

66%

with

Park

Cut Wire Shot

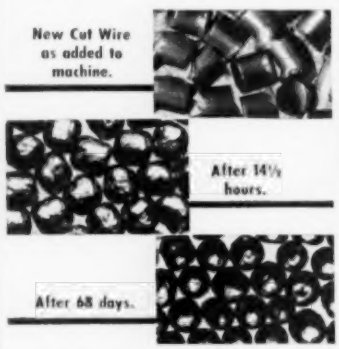
Shatter-proof Park Cut Wire Shot is made of hardened clipped carbon steel wire. It will outperform and outlast breakable cast shot. That is why you can save up to 66⅔% in cleaning and peening costs.

1. Durability
Tests prove Park shot lasts from 8 to 10 times longer.

2. Storage — Shipping
One bag of Park shot does the work of 8 bags of cast iron shot.

3. Maintenance — Wear
Sharply reduced maintenance costs and wear on equipment.

4. Material Costs
Definite savings on steel costs when peening with Park shot.



Write for bulletin and prices.

PARK CHEMICAL COMPANY
8074 Military Ave., Detroit 4, Michigan

LIST NO. 34 ON INFO-COUPON PAGE 158



MANHATTAN

Abrasive Wheels — Cut-off Wheels
Finishing Wheels—Diamond Wheels

Custom-made for your specific material removal problems

Foundry Snagging—Billet Surfacing—Centerless Grinding

Cutting and Surfacing concrete, granite, and marble

"Meldiscs" for rotary sanders

Grinding and Finishing stainless steel welds

Bearing Race Grinding and Finishing

Finishing Tools and Cutlery

Cutting-off—Wet or Dry Bars, Tubing, Structurals, etc. Foundry Cutting —standard and reinforced wheels

Grinding Carbide Tipped Tools

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Write to Abrasive Wheel Department

Raybestos-Manhattan, Inc.
MANHATTAN RUBBER DIVISION
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"Pur-Blac"

- Economical
- No Change in Dimension
- Corrosion Resistant
- Perfect Uniformity
- Non-Technical

The Black Oxide Finish That Penetrates Iron & Steel Surfaces

PURITAN MANUFACTURING CO.
WATERBURY, CONN.

LIST NO. 95 ON INFO-COUPON PAGE 158

HERE'S HELP for your engineer-recruitment problem

Engineers' Joint Council and The Advertising Council offer free, expert help to advertisers promoting engineering as a career.

A booklet has been prepared by The Advertising Council in cooperation with the Engineers' Joint Council to help you in recruiting engineers for the future.

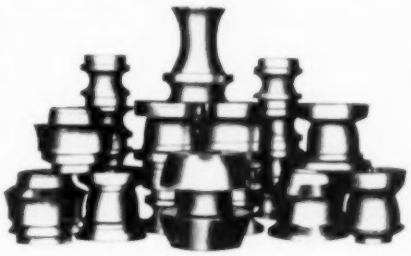
1. It tells you what the problem is and the important part you can play in solving it.
2. It outlines the advantages of an engineering career to help your company develop advertising appeals.
3. It informs you as to the current activities of industry in the education and recruitment of engineers.
4. It offers specific suggestions as to what you can do (from present manpower).
5. It provides material that you can use in your own local and national programs.

Many companies are using this booklet today. They say that it helps in orienting their engineer-recruitment advertising to industry-wide recruitment programs. Send for the booklet now. Address: The Advertising Council, Inc., 25 West 45th St., New York 36, N.Y.

This space contributed by American Society for Metals

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TUBING ROLLS
AND
FORMING ROLLS



To Your Specifications or Ardcor Design—for all makes of machines.
Also, manufacturers of Straightening, Pinch and Leveller Rolls.

ARDCOR ROLLER DIES ● ROLL FORMING MACHINERY ● CUT-OFF MACHINES

American ROLLER DIE CORPORATION

29550 Clayton · Wickliffe, Ohio

LIST NO. 57 ON INFO-COUPON PAGE 158

A CABLE SPLICED IN 10 SECONDS!



ERICO PRODUCTS, INC.
Complete Arc Welding Accessories
2070 E. 61st Place, Cleveland 3, Ohio
Write for Caddy Catalog

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RESIDUAL STRESS MEASUREMENTS

This volume, written by four outstanding authorities, devotes 204 pages to the important problem of the nature and extent of residual or "internal" stresses in metals and metal parts prior to actual structural or operati g use.

How to measure residual stresses . . . The state of stresses produced in metals by various processes . . . Relief and redistribution of residual stresses in metals . . . How residual stresses originate, their nature and their effect on metals.

204 pages, $4.50

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Prove to your own satisfaction that the MOLYKOTE line of industrial lubricants is one of the most spectacular contributions to metal progress in many decades. Send for free literature today . . . and then order a trial supply.

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INDUSTRY'S MOST VERSATILE LUBRICANT

The tremendous lubricity of MOLYKOTE depends on the unique, molecular structure of the compound. Read the story behind its development and the jobs it can do better than any other lubricants.
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THE ALPHA CORPORATION
Greenwich, Conn.

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MAURATH INC.

MANUFACTURERS • PROCESSORS
OF STAINLESS
AND HEAT RESISTANT
ARC WELDING
ELECTRODES

★ ★

AUTOMATIC WELDING

ALL ANALYSES—COATED, STRAIGHTENED AND CUT, OR COILED

Telephone:
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MAURATH, INC.
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NORTH RANDALL (CLEVELAND 22), OHIO

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STEELWELD PIVOTED BLADE SHEARS

Radically Different

Steelweld metal-cutting shears are entirely new with advantages never before possible. Revolutionary pivoted-blade travels in circular path and overcomes handicaps of ordinary guillotine-type shears. No slides or guides to wear and cause inaccuracies. Many other important features. Complete line machines for shearing metal up to 20 feet long or in thicknesses to 1-1/4 inch.



FEATURES GALORE

1. All-welded solid one-piece frame.
2. Electric foot control.
3. Fast Micro-Set Knife Adjustment.
4. Deep throat for wide slitting.
5. Lift-up Back Gauge.

Straight Accurate Cuts

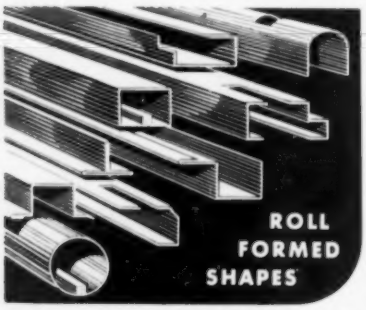
Not only are these machines easier to operate but their design assures smooth straight cuts to hair-line accuracy for years of operation. Their construction is extra heavy, and all modern features are incorporated to provide for ease of operation, minimum maintenance and long life.

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THE CLEVELAND CRANE & ENGINEERING CO.

5939 East 282nd Street • Wickliffe, Ohio

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Reduce your assembly problems and costs. Our shapes continuously formed, with high degree of accuracy, from ferrous or non-ferrous metals. Write for Catalog No. 1053.

ROLL FORMED PRODUCTS CO.

MAIN OFFICE AND PLANT
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RUST-LICK
IN AQUEOUS SYSTEMS

For
HYDROSTATIC TESTING

Eliminates . . . .

Rust
Fire Hazards
Toxicity
Dermatitis
Washing

WRITE FOR FREE SAMPLE & BROCHURE

PRODUCTION SPECIALTIES, INC.
755 BOYLSTON STREET
BOSTON 16, MASS.

LIST NO. 105 ON INFO-COUPON PAGE 158

Cut Costs With
FREE
Cutting Oil Chart

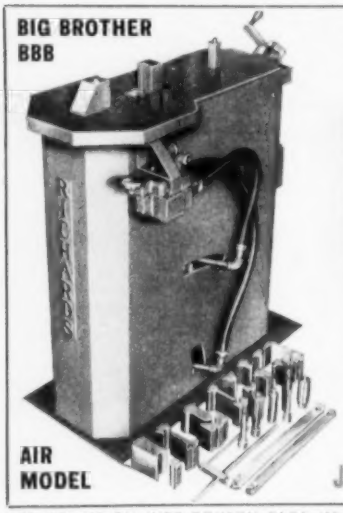
Use this free cutting oil chart as a handy guide to production costs and to more efficient machining operations.
Steel and nonferrous metals are charted with the proper cutting oil for many applications. Shows you how to use lubricants, sulphurized or compounded with extreme pressure additives, for all operations.



ALDRIDGE INDUSTRIAL OILS, Inc.
3401 W. 140th St., Cleveland 11, Ohio

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BIG BROTHER BBB



AIR MODEL

Multiform



Illustrated above are a few of the many forms that can be produced efficiently on the Multiform Bender, using the standard tooling.

WRITE TODAY FOR FULL INFORMATION

BENDERS-CUTTERS
20 MODELS
FOR BENDING ALL KINDS OF MATERIALS up to ¼" x 4"

GREAT SAVINGS

#5HDSB

Also build #5 AIR MODEL



J. A. RICHARDS CO. • 913 N. Pitcher St. • Kalamazoo, Michigan

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Increased Production

Longer Die Life

Less Scrap

These are claims of users of HANGSTERFER'S LUBRICANTS who are Drawing, Drilling, Reaming or Tapping stainless steel or other hard metals.

HANGSTERFER'S LUBRICANTS are doing the job for major metal working plants here in the United States and in Europe.

HANGSTERFER'S LABORATORIES

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WOODBURY, NEW JERSEY

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Use Atlantic Fluxes

ALUCO . . .
For degasifying and purifying aluminum alloys. Assures uniformly sound, dense grained castings. Used in reverberatory and crucible-type furnaces.

ALUCO 'S' . . .
Specially compounded for die casting aluminum-base metal and permanent mold castings.

MAGNESAL . . .
Used for removing magnesium from aluminum alloys.

ALUCO 'GR' & 'DG' . . .
For grain refining and degasifying aluminum and its alloys.

Atlantic Chemicals & Metals Co.
1921-27 NORTH KENMORE AVE.
CHICAGO 14, ILLINOIS, U.S.A.

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Solve
EXTREME PRESSURE LUBRICATION *with*



***The new miracle*—multi-purpose molybdenum disulfide lubricant.**

Anti-Seize is a stable non-melting lubricant having a phenominal capacity to prevent seizing and galling at bearing pressures well over 100,000 pounds per square inch. Anti-Seize will lubricate at temperatures below sub-zero and up to 750 degrees F.

Write today
DEPT MP
for new literature
and get the
complete story

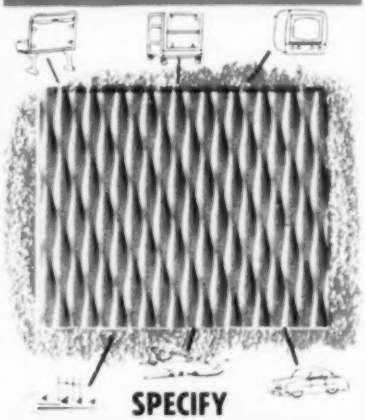


MANUFACTURERS OF THE MOST COMPLETE LINE OF MOLYBDENUM DISULFIDE LUBRICANTS

BEL-RAY CO., INC.
MADISON, NEW JERSEY

LIST NO. 111 ON INFO-COUPON PAGE 158

STRENGTHEN BEAUTIFY PROTECT your product



SPECIFY
RIGID-tex METALS

Take that new product of yours, make it dent-scuff-scratch-resistant, give it plenty of rugged impact resistance, reduce its weight and double its strength, and finish it up by packing it full of buying-eye appeal. You can do *all* this when you specify Rigid-Tex Metals right into your product designs! Find out for yourself.

Write on your company letterhead.

RIGIDIZED METALS CORPORATION
6210 Ohio St., Buffalo 3, N. Y.
U. S. & Foreign Patents

35 Warehouses and Sales Representatives in All Principal Cities Throughout the U. S. and Canada

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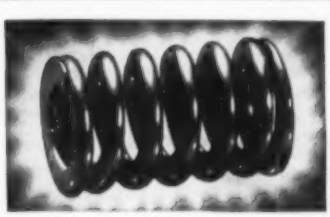
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your comprehensive independent source of magnesium alloy
Tubes • Rods • Shapes • Bars
Hollow Extrusions • Plate • Sheet
• Pipe • Wire • Welded and Riveted structures and assemblies

WHITELIGHT MAGNESIUM

WHITE METAL ROLLING & STAMPING CORP.
82 Moultrie St., Brooklyn 22, N. Y.
Sales Office
376 Lafayette St., New York 3, N. Y.

LIST NO. 47 ON INFO-COUPON PAGE 158



COMPRESSION • TORSION • FLAT • EXTENSION • AND SPECIAL TYPE SPRINGS

METAL STAMPINGS AND WIRE FORMS

JOHN EVANS' SONS, Inc.
131st & NECTARINE STREETS
PHILADELPHIA 23, PENNA.

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EpCo

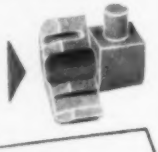
A PROVEN DEPENDABLE SOURCE

FOR BETTER GRADE INVESTMENT CASTINGS IN FERROUS AND NON-FERROUS METALS



INVAR CASTING Special Feature — Nickel content held to 35% minimum — 36% maximum

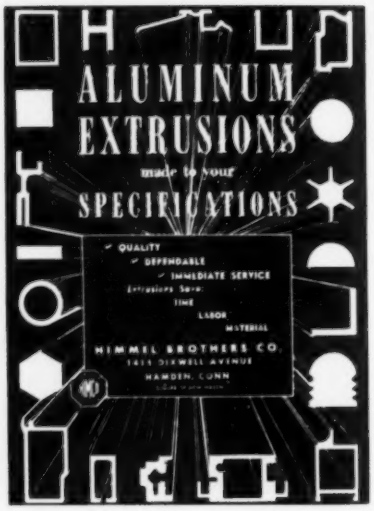
STAINLESS STEEL PART for milk bottling unit formerly machined from solid stock. Only finish operations required are reaming small dia. of counterbored hole and drilling and tapping for set screw.



ENGINEERED PRECISION CASTING CO.

MORGANVILLE, N. J.

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SINCE 1922

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THE HOOVER COMPANY
Die Castings Division
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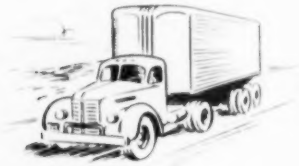
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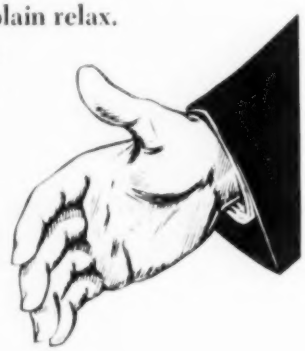
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The week of

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From Star to Vega and Beyond

CAREFUL distillation of over half a century of operating experience in 32 widely scattered plants producing a wide range of refractory shapes has yielded some superlatives for Harbison-Walker's new silica brick plant at Windham, Ohio. Particularly impressive are methods of handling and storing raw materials, control of particle sizes in the brick mixtures, precision of batching and mixing, power press operations in forming green brick, and two immensely long tunnel kilns for firing brick—not to mention an unusually elaborate system of dust collection and suppression.

This plant represents the largest unit operated by the company, in terms of floor space (200,000 sq. ft.) and, at full capacity, it can turn out 30,000,000 brick a year. This figure is based on what is called "9-in. equivalent"—that is, a unit equal to the volume of a standard 2½x4½x9-in. brick. Naturally there are many shapes much larger than this, as well as many of irregular contour such as skew blocks for openhearth roofs; the 9-in. equivalent is taken as a reference size.

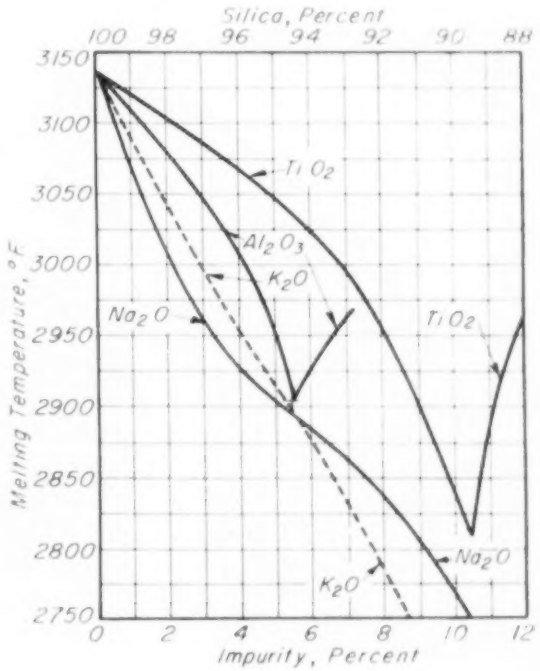
Over the past few years Harbison-Walker Refractories Co. has been keeping pace with rapid expansion in steelmaking and other industries using its products. As a gage of this effort, it may be noted that as of June 1951 there were 18 continuous tunnel kilns operated in the company. Now there are 30.

Of all commercial refractories, silica brick come closest to the pure oxide. A quartzite or ganister base usually contains more than 98% SiO_2. In manufacture, about 2% of high-purity lime (CaO) is added for bond. The resulting brick, then, is a mixture of about 96% silica, with 2% lime and 2% other oxides in which alumina and iron oxide predominate, although there may be some titania (TiO_2) and alkalis such as sodium and potassium oxides.

Brick of this composition have been on the market for well over half a century. They combine high mechanical strength and refractoriness with relatively low density or unit weight. Also they are not very expensive, as refractories go. In the effort to improve—that is, to get a brick which would hold its strength at higher operating temperatures—Harbison-Walker has devoted much scientific and commercial research. It may be said that the amount of viscous liquid present in a firebrick at high temperatures is a measure of strength loss, so a reduction in this percentage can be expected to lead to better high-temperature strength. The worst offenders proved to be alumina, titania and the alkalis. By reducing the total content of these constituents to a maximum of 0.5%, a brick could be produced that would not crush under the standard load test at 50 psi. until the temperature was 50 to 100° higher than the corresponding figure for conventional silica brick. Figure 1 shows effects of accessory oxides on the melting behavior of silica.

This, briefly, is the story behind the "superduty" silica brick, introduced first during World

Fig. 1—Effects of Four Impurities or Accessory Oxides Upon the Melting Behavior of Silica. Reducing the amounts of titania, alumina and alkalis present improves the hot strength of silica brick



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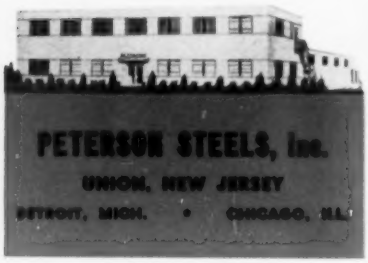
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Improved Silica Brick

War II but available in limited quantities until recently. It is now being produced at the Windham plant, along with silica brick of the regular type. Harbison-Walker identifies them as "Vega" and "Star," respectively. The trade-names were fitted into an intriguing subtitle—"From Star to Vega and Beyond"—in a company history published last year on the occasion of Harbison-Walker's 50th anniversary.

Silica brick are used extensively in many types of melting furnaces, both for new construction and maintenance. Included are openhearth and electric steel furnace roofs, by-product coke ovens, glass "tanks," copper reverberatory furnace roofs, copper and nickel refining furnaces, wire-bar and anode furnaces, vertical-shaft lime kilns and a few others. They find use in sprung-arch roofs of all sorts of heating furnaces, differing widely in their applications.

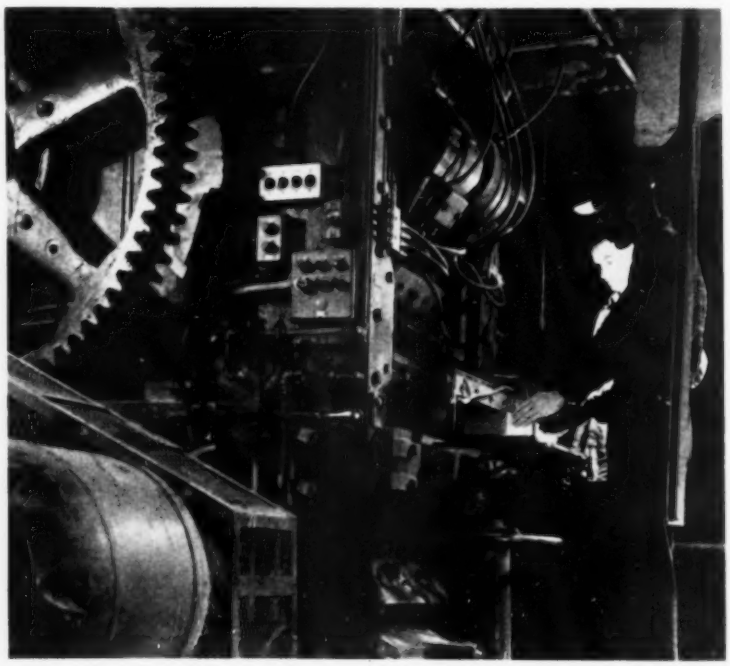
With this brief classroom dissertation on the generalities of the product, it may be pertinent to turn to some of the noteworthy features of the Ohio plant, three quarters of whose output, by the way, is trucked to the steel industry in Ohio and western Pennsylvania.

In addition to being close to customers, Windham is close to raw material. The quarry at Nelson's ledges, only six miles north contains ample reserves of high-grade silica conglomerate of the Sharon geological formation, which is crushed and washed at the site before being trucked to the brick plant.

MECHANIZED OPERATIONS

A quick rundown of the basic steps in manufacturing silica brick is as follows: raw material handling and storage, grinding, screening, ball milling, batching, mixing, forming, drying and firing. It is not necessary to detail each step. A few highlights will indicate the degree of mechanization and control which has been engineered into the Windham plant. These are factors which could apply to almost any manufacturing or processing operation, in the light of present-day conditions, being not altogether peculiar to refractories production. To achieve them and to make them work, a minimum of

Fig. 2—Mechancial Press Forming Green Brick Under Pressure of 5,000 Psi. Flexible lines are a part of the centralized press lubrication system. Abrasiveness of the material limits die life to an average of 15,000 brick



brawn and a maximum of brain are essential—all the way from supervision through engineering and research to the operating level.

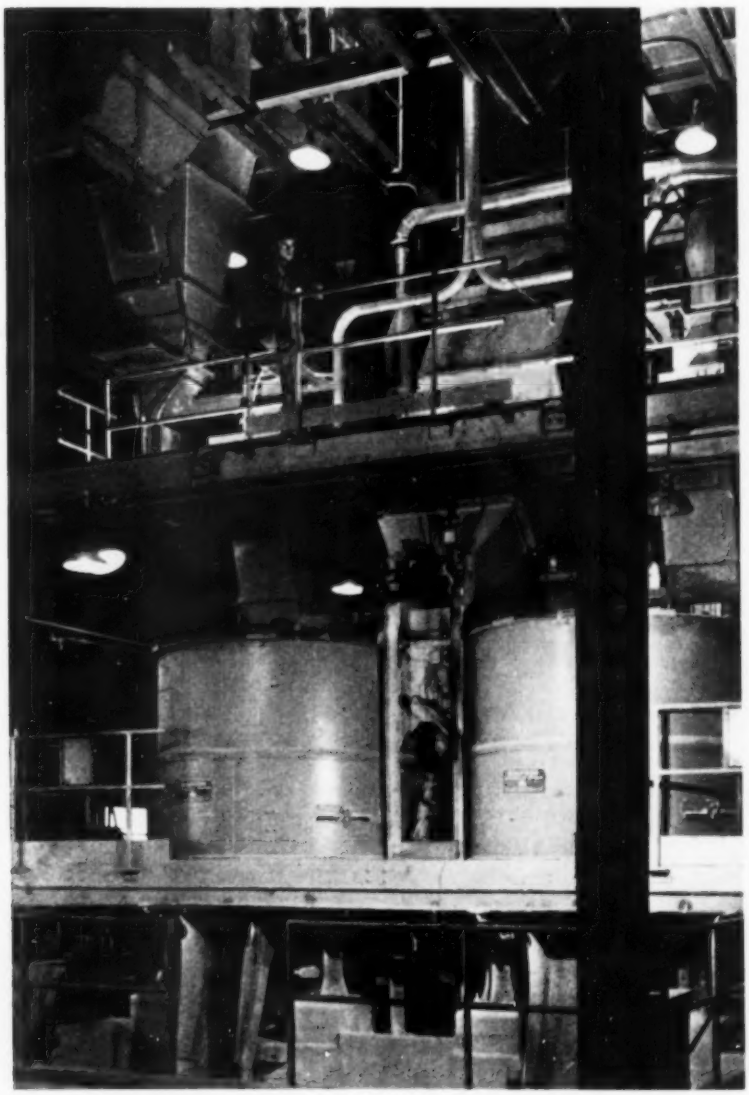
Intensive engineering study and planning were poured into the design of batching and mixing systems. Brickmaking with wheelbarrow and shovel is as antique as sun-dried adobe.

Materials are discharged from the selected ground stock bins in the exact weight proportions, then are batched, delivered to mixers and discharged to tram buckets. For all this the only manual effort required is to push the proper buttons on a master control panel. Relays and solenoids do the rest. If anything goes wrong, such as a jammed gate valve or a clogged conveyer, the entire system stops, a horn blasts and telltale lights flash at the trouble spot.

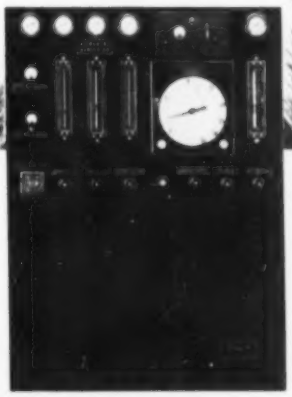
Mixers are totally enclosed stationary pans with rotating mullers and scrapers, similar to those for mixing molding sand. Feed comprises the ground and properly proportioned silica raw materials, about 6% water and binders. All materials arrive in a predetermined sequence and mixing times are standardized. Contents are discharged to buckets which are

(*Continued on p.* 164)

Fig. 3—Raw Materials Are Fed Into These Two Mixers Automatically in Proper Amounts and Sequence. After mixing, they are discharged into tramrail buckets shown at the extreme top, waiting to be lowered under the mixer chutes



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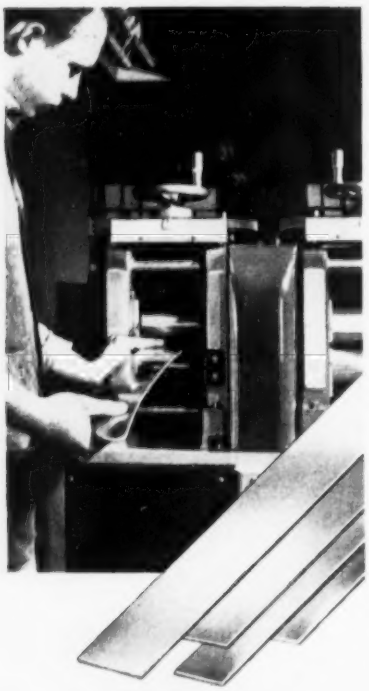
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STANAT

Improved Silica Brick

(*Continued from p. 163*)
then hoisted to an overhead tramrail system and switched to hoppers above a press or a special-shape molding machine.

The power presses which form the standard green bricks operate at about 8 strokes per min. and make one to four brick per stroke, depending on size. The pressure is about 5000 psi. The press crews set the brick directly on tunnel kiln cars—a simple scheme which eliminates one handling and is said to be unique for silica brick, although there seems to be no reason why it should not have been done before.

Shapes of such complicated design that they cannot be formed by the power press are molded by impact press or by hand.

The brick, on cars, move through tunnel driers, heated to about 320°F. by waste gases from the firing kilns. From the driers the cars are transferred directly to one of two tunnel kilns for firing. These units are 567 ft. long, 6x5 ft. clear inside, and accommodate 81 of the 7-ft. kiln cars. It takes 4 days for a car to move from end to end, the entire train being inched along by a hydraulic pusher at the charging end.

At present, kilns are fired with heavy oil. Each oil line has a parallel small steam line to heat the oil for proper fluidity, the two lines being wrapped together with insulation. Hot air at 700°F. goes from the cooling zone of the kiln to the burners as combustion air. Eventually it is expected to switch to gas firing, which will require only a change of burner lances.

Kilns are provided with both thermocouple and radiomatic instruments for temperature measurement of each of the 79 zones (one per car) along their length. This instrumentation allows the operator to set up any desired firing curve, within rather wide limits, and also permits close adjustment of individual burners for uniform heating conditions.

A double door and vestibule at the kiln entrance prevent any large disturbance to draft conditions and fuel-air ratios when charging a new car. Careful insulation prevents excessive heat loss by radiation from walls and crown; the insulation thickness varies from section to section, depending upon the operating temperature desired.

Additional firing can be handled by two outside periodic kilns with the familiar dome. They are used mainly for intricate or special shapes and have a cycle time of about 21 days. Loading and unloading are relatively slow and cumbersome in

(*Continued on p. 166*)

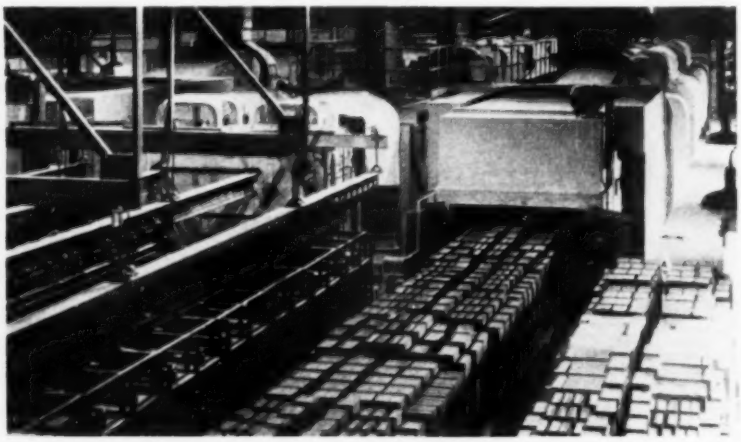
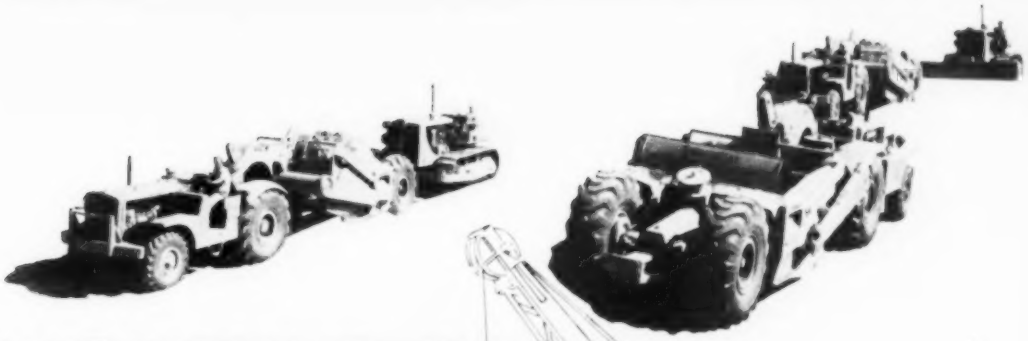


Fig. 4—Unburned Brick, Carefully Stacked on Tunnel Kiln Cars, Here Are Entering Drier Before Moving on Through 567-Ft. Firing Kiln. To the left are special refractory shapes carried on racks by monorail. A separate "rack car drier" is used to dry them and they are fired in periodic kilns



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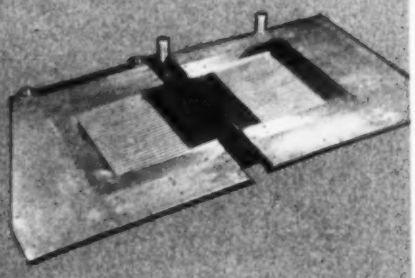
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Silica Brick

(*Continued from p.* 164)

comparison with operations in the continuous kilns.

The plant layout was based on handling palletized shipments insofar as possible. From kiln car unloading through the stock shed, to shipping docks, lift trucks and pallets do the work, dispensing with conventional transfer pits and depressed kiln car tracks. Pallets are reusable, made of hard wood. In storage areas, loaded pallets are stacked four high.

Where fine silica, some of it 150 mesh and under, is being handled, there is the ever-present danger of the lung disease silicosis. Three precautions minimize this hazard at Windham. First the grinding and screening equipment, where dust generation is heaviest, is completely enclosed. Second is the provision of adequate dust-collection devices; separate dust systems serve the raw material processing equipment and the grinding area, while portable high-vacuum units take care of general plant clean-up and cleaning the tunnel kiln cars.

Finally, the company provides its employes an aluminum inhalation treatment weekly. This powdered-aluminum prophylaxis, developed by the McIntyre Research Foundation of Toronto, Ont., was first installed by Harbison-Walker at its Hays Works in 1943 and since has met widespread acceptance.

Mechanization, precision control, high production per man-hour, continuing research of both basic and operating types, combined with the best working conditions which engineering can devise, make the Windham plant a strong link in the Harbison-Walker chain. Proximity to raw materials and customers, plus ample room for future expansion, may indeed take it far beyond Star and Vega.



Digests of ASM Convention Papers

High-Strength Titanium Alloys*

TITANIUM ALLOYS with beta-stabilizing elements (Fe, Cr, Mn, Mo) at lower concentrations transform to alpha by a martensitic type reaction. Under some conditions, these alloys are age hardenable. Above a certain content of alloying elements, beta is completely stable. This investigation is concerned with alloy contents of 7 to 8% in which beta is stable and in which age hardening is the important metallurgical reaction. Age hardening is thought to be a result of a coherent alpha precipitate.

Three titanium alloys were studied containing (*a*) 3.5% Cr, 3.5% V, (*b*) 5% Mn, 2.5% Cr, (*c*) 1% Cr, 1% Fe, 3% Mn, 1% Mo, 1% V. The alloys were tested as 0.064-in. thick sheet and 0.5-in. diameter bar stock. The alloys were found to be 100% beta above 1500 to 1600° F. The alloys were studied in the solution treated condition. One hour at 1300° F. produced the lowest hardness. The maximum tensile strength obtained was 170,000 psi. for the sheet and 195,000 psi. for the bar stock, with 8 to 10% elongation. In general, the tensile strength increased with increasing solution temperature, and elongation decreased. The effect of rolling temperature was studied, and it was found that the alloys in the beta field, after rolling at 1600° F., had consistently lower ductility at a given strength level than those in the alpha-beta field. The structure of the former is Widmanstatten alpha, whereas the latter shows spheroidal alpha.

The solution temperature fixes the composition and therefore the stability of beta. The degree of hardening depends upon the amount of coherent alpha formed, which decreases as the stability of beta increases. Good tensile properties may be obtained by solution heat treatment. However, these alloys are of limited usefulness since the retained beta undergoes precipitation hardening above 200° F.

Although high strength and good ductility are obtained for the alpha-beta alloys by quenching or air cooling from a solution treatment, this hardening treatment is not easy to control. It was found that considerably better and more reproducible properties may be obtained if the alloys are actually overaged by holding for relatively long periods of time at temperatures between 800 and 1100° F. Maximum hardening after all solution treatments occurs at 700° F. Strengths of over 200,000 psi. with elongations of 10% can be obtained by overaging in this temperature range. Solution treatment of 1600° F. prior to overaging reduces ductility in all the alloys.

The effect of temperature at time of rolling prior to heat treatment was investigated. It was found that the ductility of each alloy was reduced as the rolling temperature increased from 1450 to 1600° F., although in varying degree among the three alloys. The excellent tensile properties developed by overaging are believed to be due to the dispersion hardening effect of fine alpha precipitate in the retained beta in which coherency of the precipitate is completely lost. A good correlation was found between Vickers hardness and tensile strength in overaged alloys.

The stability at elevated temperature of the overaged alloys also was investigated. The properties of two of the three alloys, heat treated to about 200,000 psi. tensile strength, were essentially unchanged after 1000 hr. at 500° F. The third alloy (Cr-Fe-Mn-Mo-V), heat treated to 214,000 psi. tensile strength, is stable up to at least 500 hr. at 500° F. Thus, overaging produces high strength and good stability at elevated temperatures.

J. W. SPRETNAK

*Digest of "Heat Treatment of High-Strength Titanium-Base Alloys", By W. M. Parris, P. D. Frost, and J. H. Jackson. ASM 1953 Preprint No. 4.

Recrystallization and Grain Growth*

THE EQUATION of Hollomon and Jaffe, which already has been applied successfully to creep, rupture and tempering phenomena—namely

$$T(C - \log t) = \text{constant}$$

(where T is absolute temperature, C is a material constant, and t is time) is applied to recrystallization and grain growth, since these also are rate processes dependent on diffusion. The limited data available in the literature were used to test the validity of this premise.

When a value of 20 was selected for the material constant, C, plots of either hardness or fraction recrystallized against the parameter T (20 — log t) gave a single "master curve" for a given material (for three different copper-base alloys, for zirconium, and for aluminum) and degree of initial reduction by working (5 to 71.5%). A similar master curve was demonstrated for grain growth (for two copper-base alloys, nickel, iron, zirconium, and two aluminum alloys) by a plot of grain size against the parameter.

In determining the effect of specimen size on grain growth (for alpha brass) it was found that each master curve was composed of two segments: A straight portion, which is called the "absolute rate of grain growth" and is independent of specimen size, and a curved portion which is dependent on specimen size. A similar observation was made for the effect of increasing degrees of cold work (for nickel, and for iron). The degree of cold work determines the grain size at which the absolute rate of grain growth starts. The rate of growth is low just after recrystallization has taken place and remains low until the straight-line portion of the curve is reached.

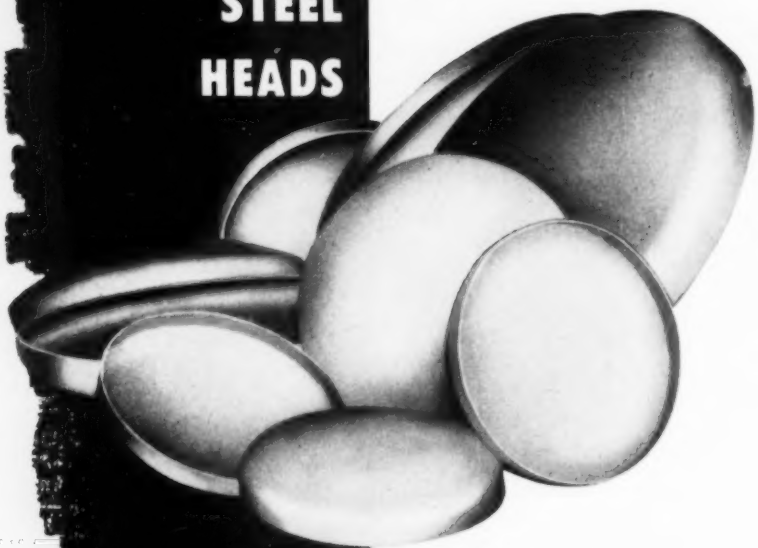
(Continued on p. 168)

*Digest of "A Time-Temperature Relationship for Recrystallization and Grain Growth", by F. R. Larson and J. Salmas, ASM 1953 Preprint 10.

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District Sales Offices in Principal Cities

Recrystallization and Grain Growth

(Continued from p. 167)

The presence of an insoluble second phase (for Al-Mn alloys) appears to limit grain growth without altering the absolute rate of grain growth; its effect is somewhat analogous to that of specimen size.

In solid solution alloys, if the solute and solvent atoms are similar enough so that an extensive range of solid solution exists (for Al-Mg alloys), increased additions of the alloying element have little effect on the absolute rate of grain growth but do appear to affect the recrystallized grain size. On the other hand, if the solute and solvent atoms are different (for Al-Mn alloys) the absolute rate of grain growth is retarded markedly by increasing the amount of alloying element, and the recrystallized grain size is much finer for higher alloy than for lower alloy material under identical conditions of cold work.

C. H. SAMANS

Transformation and Mechanical Properties of Ti-Al-Mo Alloys*

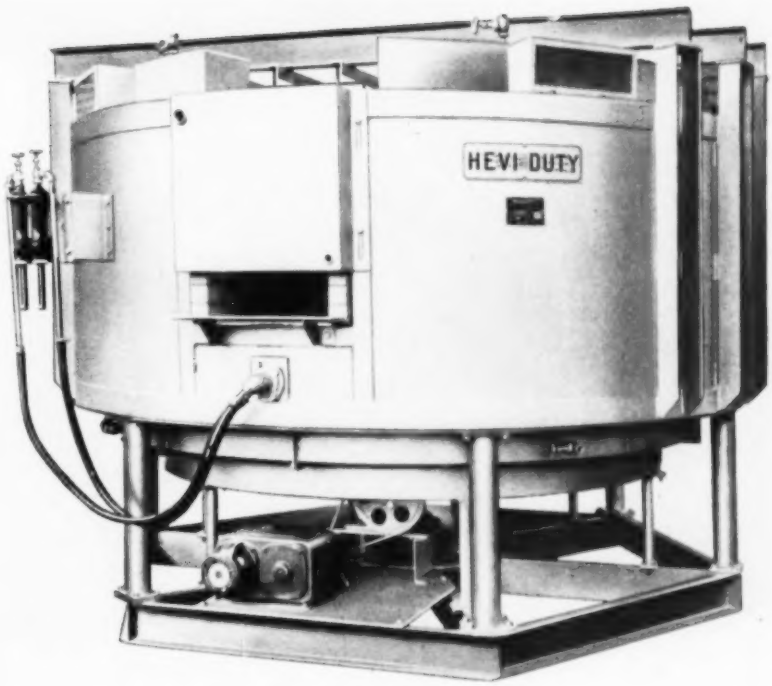
THIS STUDY represents part of an investigation of the influence of ternary elements on the properties of titanium-aluminum alloys. The Ti-Al-Mo system is an example of a combination of a beta-stabilizing terminal solid solution (Ti-Mo) and an alpha-stabilizing terminal solid solution (Ti-Al). The Ti-Cr system is of the eutectoid type.

The Ti-Mo system shows a maximum hardness after quenching at a low alloy content due to the formation of acicular transformed beta (α') structure by a martensitic-type reaction. At a higher alloy content, α' disappears and a higher hardness is obtained by the aging of the beta alloy in the $\alpha + \beta$ field. The hardness increase caused by aging results from the rejection of alpha from supersaturaated beta. In the Ti-Cr system, the maximums for water

(Continued on p. 170)

*Digest of "Transformation Kinetics and Mechanical Properties of Titanium-Aluminum-Molybdenum Alloys", by H. D. Kessler and M. Hansen, © 1953 Preprint No. 5.

How GLOBAR® Heating Elements CUT LABOR and MAINTENANCE COSTS in Industrial Heating



● Furnace manufactured by Hevi Duty Electric Co., Milwaukee 1, Wisconsin.

In overall operating economy, you'll find it hard to beat an industrial furnace equipped with GLOBAR® Brand silicon carbide heating elements . . . even when electricity costs more than other fuels. Furnaces using GLOBAR elements, such as this Hevi Duty Rotary Hearth Furnace, feature maximum simplicity of design. They are far easier to operate. Maintenance costs are slashed to a minimum.

Fuel storage and handling are eliminated. There are no complicated fuel regulators—no artificial terminal-cooling devices—to get out of order. And because less auxiliary equipment is needed, furnace construction is more rigid. Operating efficiency is tops because the heat from the GLOBAR elements is confined to the chamber—where you want it. The heat is fast, clean, quiet, safe, uniform . . . and accurately controlled. The ends of the elements extend through the furnace to permit replacement, when necessary, without cooling or unloading.

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GLOBAR Heating Elements give you

1. **MORE UNIFORM HEATING** of hearth area.
2. **WIDEST RANGE OF TEMPERATURES...** up to 2750°F.
3. **SIMPLICITY** of furnace construction and operation.
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THE HEVI DUTY FURNACE SHOWN HERE also uses hearth plates and sill plates by CARBORUNDUM® for extra long life. Products of Refractories Division, The Carborundum Company.

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Transformation and Mechanical Properties of Ti-Al-Mo Alloys

(Continued from p. 168)

quenching and aging occur at about the same composition.

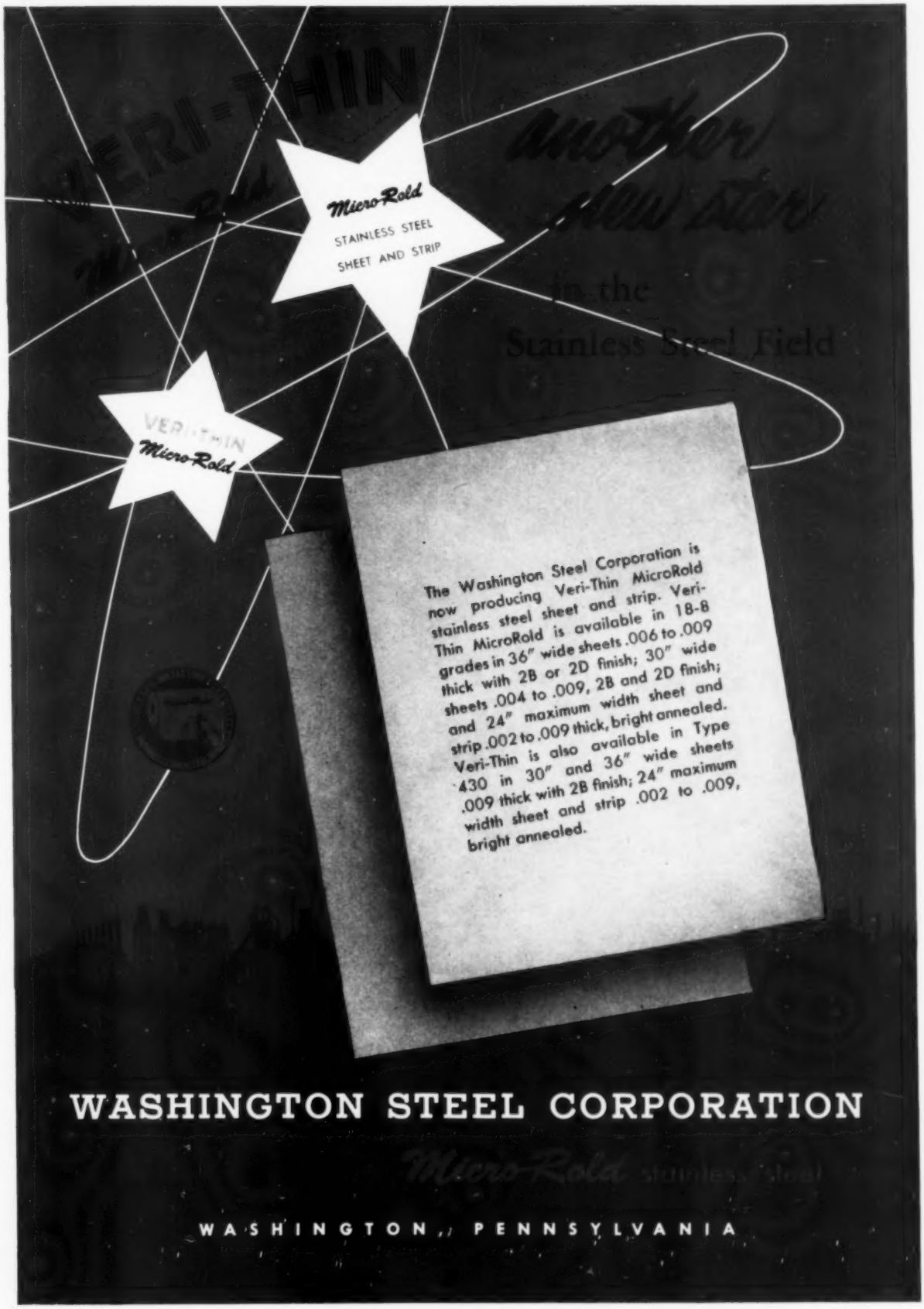
The heat treating characteristics of the Ti-Al-Mo alloys were established by end-quench hardenability, time-temperature transformation, age hardening, and studies of mechanical properties. Alloys were prepared by a double-melting process to insure homogeneity. In the first melting, a nonconsumable tungsten electrode was used, whereas in the second melting a ½-in.-diameter rod of the same alloy as the alloy being prepared was used as a consumable electrode. The alloys were forged in the beta temperature range to ⅝-in. rounds and squares. The nine alloys studied had a maximum molybdenum content of 10% and a maximum aluminum content of 6%. Most of the heat treatments were carried out in vacuum-sealed Vycor bulbs.

The effect of rate of cooling from the beta field was studied by means of the end-quench hardness tests. The 2% Mo alloys showed little variation of hardness along the length of the bar. The 6% Mo alloy had a minimum hardness at the quenched end and became progressively harder with reduced cooling rate. The 10% Mo alloy consists almost entirely of retained beta.

The time-temperature-transformation diagrams are similar to those for Ti-Mo alloys, consisting of two C-curves marking the beginning and completion of the $\beta \rightarrow \alpha + \beta$ reaction. The $\beta/\alpha + \beta$ transformation is lowered by molybdenum and raised by aluminum. The nose of the C-curve lies between 600 and 700° C. (1110 and 1290° F.) for all the alloys. Molybdenum decreases and aluminum increases the reaction rates. Aluminum slightly reduces Ms for α' for a given molybdenum content.

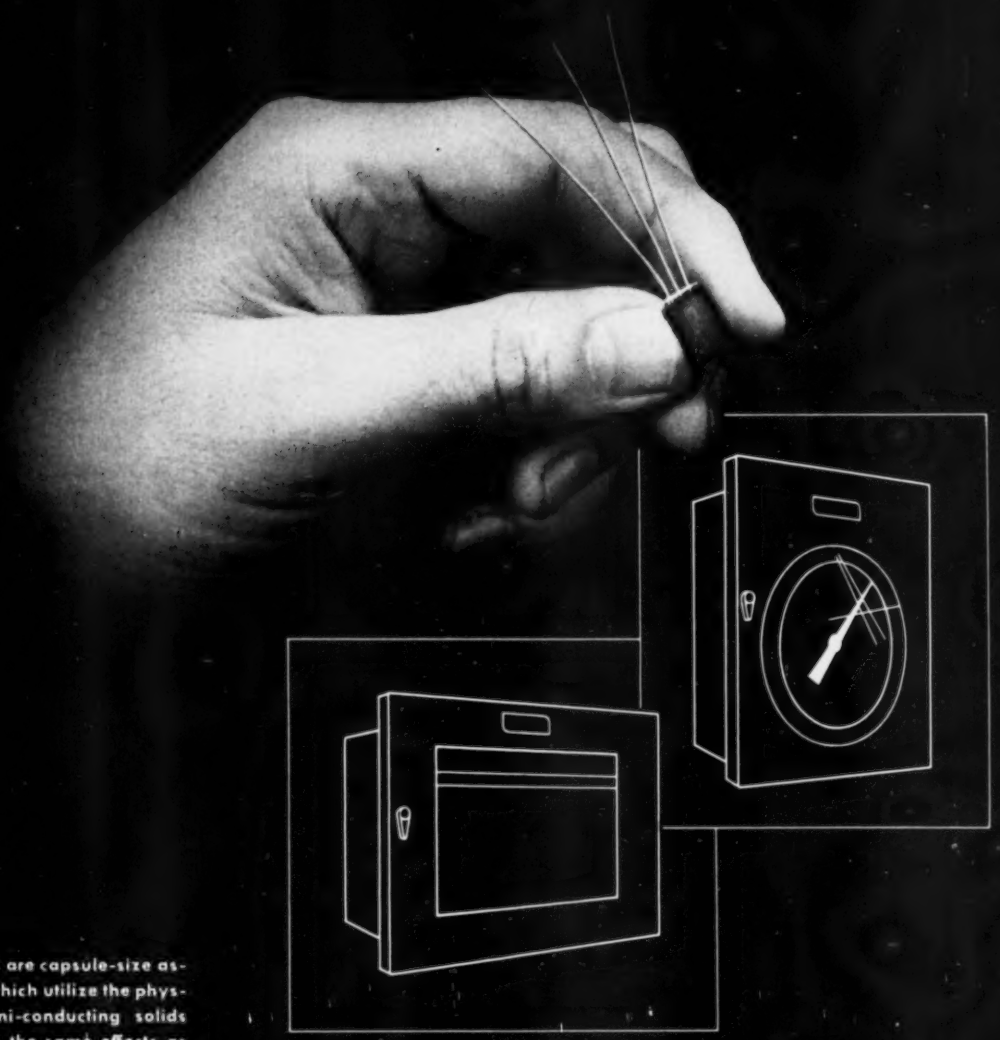
It seems that 600° C. is the optimum aging temperature to produce a high hardness in a short time. Hardness peaks are reached in 1 min. for 2% Mo alloys, in 100 min. for 6% Mo alloys, and in more than 100 min. for the 10% Mo alloys. The

(Continued on p. 174)


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STAINLESS STEEL
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new star
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Micro-Rold
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WASHINGTON STEEL CORPORATION
Micro-Rold stainless steel
WASHINGTON, PENNSYLVANIA

Transistors*

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*Transistors are capsule-size assemblies which utilize the physics of semi-conducting solids to produce the same effects as an electronic tube . . . but without cathode and/or filament and their circuitry components.

When ?

A timely statement from Walter P. Wills,
Director of Research, Brown Instruments Division
Minneapolis-Honeywell Regulator Co., Philadelphia 44, Pa.

"PERHAPS you've wondered when transistors, with their widely publicized characteristics, will be put to work in industrial instrumentation. Naturally, I can speak only for my company, but I'd like to give you a research man's view on where transistors stand today.

"We agree that transistors have a tremendous future in all of electronics, including automatic control. Many problems, however, must yet be solved. Will they be made of germanium or silicon? Can they be made more reproducible and able to handle enough power at desired voltages? New circuits and new transistor types are needed. Today's costs are much too high. And let's not forget that the vacuum tube is still being developed after more than 40 years of existence.

"Even with extensive research and development programs, much more work remains before transistors can be broadly utilized in their natural markets—radio, television, and other communication equipment. Similarly, the few types now available do not nearly satisfy the requirements of industrial instrumentation.

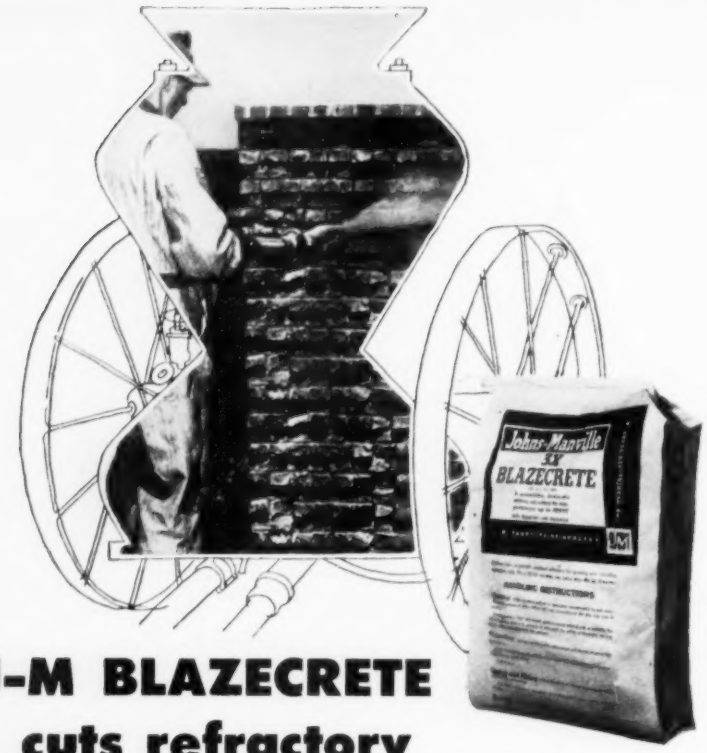
"A 'tubeless' electronic instrument is theoretically possible today, and, on the basis of safety and reliability expected of modern instruments, it is anticipated that such a product is completely possible and practical in the future.

"So we're attacking the problem on a broad front. For upwards of five years, we've been devoting a large portion of our research facilities to studying ways to utilize transistors . . . looking on them not solely as replacements for tubes, but as the starting point for totally new instrument circuits.

"In addition, we have invested in the patent licenses and the know-how of Bell Telephone Laboratories, the pioneer of transistors. We have a large stake in providing instrumentation for the manufacture of transistors and hence are examining all facets of the transistor business . . . even to the extent of making some with our own hands.

"Honeywell instruments and other Honeywell controls using transistors will be on the market. When they are, you can be sure they will be great products—new, but the same kind of reliable, versatile, well-engineered products we sell today."

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BROWN INSTRUMENTS
First in Controls



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That's why it pays you to use this hydraulic-setting refractory for temperatures to 3000F

Blazecrete* materially reduces labor costs for refractory maintenance. This hydraulic-setting refractory saves time in building and repairing linings for high-temperature equipment.

For troweling, just mix Blazecrete with water as you'd mix ordinary concrete . . . then slap-trowel it in place. When gunned, it adheres readily with a minimum of rebound loss. Either way, Blazecrete goes on fast, without laborious ramming or tamping. And Blazecrete linings *last.*

Three types of hydraulic-setting Blazecrete are available. All harden on air curing, do not require prefiring. They are furnished as a dry mix—can be stored safely for use as needed.

3X BLAZECRETE—For temperatures through 3000F. Unusually effective for heavy patching, especially where brickwork is spalled or deeply eroded. Excellent for forge furnace linings, lime kilns, burner blocks, soaking pits, and industrial boilers.

STANDARD BLAZECRETE—For temperatures through 2400F. Makes repair work easier and less costly. Can be used by boiler manufacturers to replace fire clay tile in wall construction. Suitable for use in combination with 3X Blazecrete and L. W. Blazecrete.

L. W. BLAZECRETE—For temperatures through 2000F. An insulating refractory . . . light in weight, low in thermal conductivity. Adaptable and economical for many other applications.

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Whether you gun it...  *or slap-trowel it...* 

Johns-Manville **BLAZECRETE**

BUILDS BETTER REFRACTORY LININGS

Transformation Kinetics of Ti-Al-Mo Alloys

(Continued from p. 170)

maximum hardness is higher in the 4 and 6% Al alloys than in the 2% Al alloys for a given molybdenum content. The alloy with 2% Al and 10% Mo offers the greatest heat treatable range (Vickers 300 for as-quenched and 500 for as-aged).

The trends in mechanical properties are mainly dependent on the amount of molybdenum added to the Ti-Al alloy. There is little advantage in strength in aluminum contents of 4% and over; the higher aluminum contents cause poor ductility (2% Al is best). Alloys with low molybdenum (about 2%) attain high hardness on water quenching; alloys of intermediate molybdenum (about 6%) are both quench and age hardenable; alloys of high molybdenum (about 10%) attain maximum hardness only on aging of supersaturated beta solid solution. Substantial variations in strength and ductility can be obtained in alloys containing 2% Al and up to 6% Mo by simply varying the cooling rate from the beta solution treating temperature. Although variations in cooling rates resulted in relatively small variations in strength for the alloy with 2% Al and 10% Mo, the tensile ductility is considerably affected.

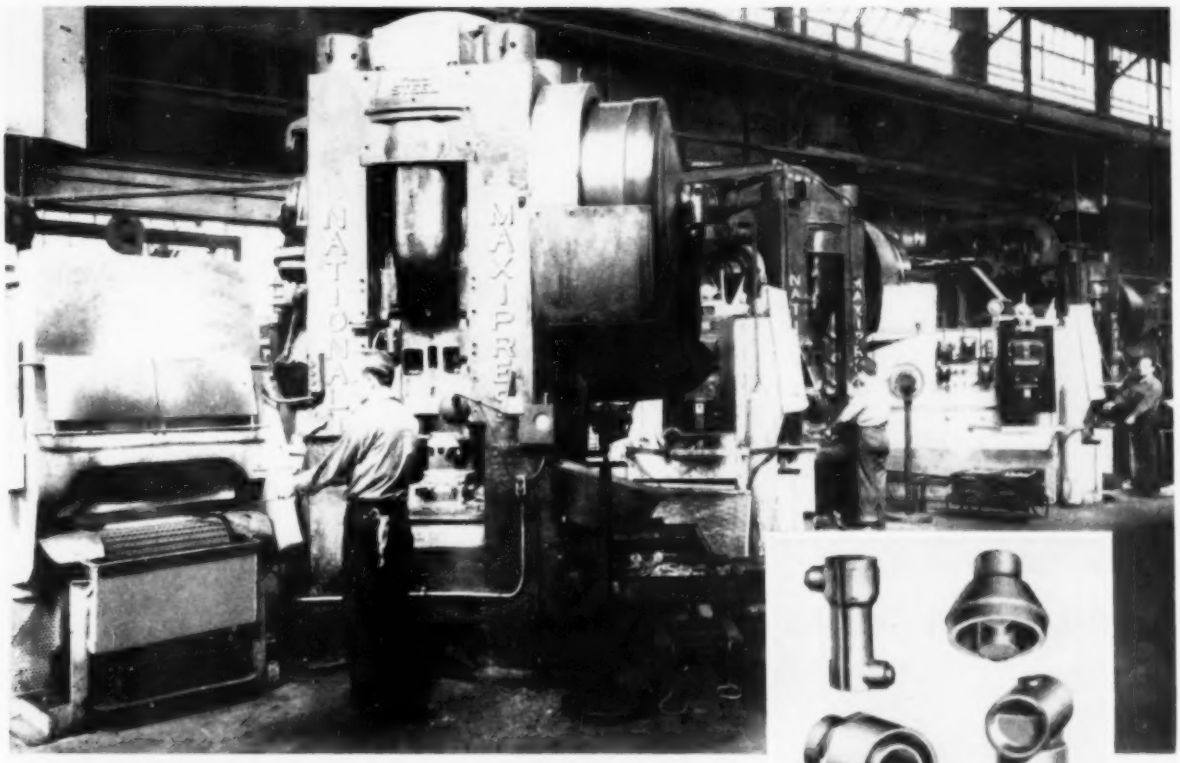
J. W. SPRETNAK

Transformation and Mechanical Properties of Ti-Al-Cr Alloys*

THE EVALUATION of the heat treatment and properties of Ti-Al-Cr alloys is the second in the series of studies on the effect of a ternary addition on the properties of Ti-Al alloys. The system studied is an example of a combination of a beta-stabilizing eutectoid-type binary system (Ti-Cr) and an alpha-stabilizing terminal solid solution system (Ti-Al). Nine alloys were studied, containing a maximum of 6% Cr and 6% Al. The alloys were evaluated by means of end-quench hardenability

(Continued on p. 176)

*Digest of "Transformation Kinetics and Mechanical Properties of Titanium - Aluminum - Chromium Alloys," by H. D. Kessler and M. Hansen, © 1953 Preprint No. 6.



MAXIPRES forging operations at Titan Metal Manufacturing Co., Bellefonte, Pa.

Typical Titan forgings. Note intricate designs.



3600 TITAN Forgings Per Hour

. . . from this battery of

HIGH SPEED FORGING MAXIPRESSES!

Titan Metal Manufacturing Co., Bellefonte, Pa., specialists in quality brass and bronze forgings, is achieving outstanding production rates with this battery of three National High Speed Forging MAXIPRESSES, which reach 1,200 forgings per press per hour!

Titan forgings, many of intricate shapes with thin wall sections, vary in weight from less than one ounce up to 100 lbs. They are precision forgings, due in part to the over all ruggedness and built-in rigidity of the MAXIPRES.

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Controlled "T" shot and grit are chilled iron abrasives in which the iron carbides (that do the cutting) are imbedded in a ductile matrix—this shot actually deforms before tearing apart. Controlled "T" shot and grit are held to a hardness range below 450 BHN—the wearing parts of your cleaning equipment usually have a hardness range of from 450 to 550 BHN. Controlled "T" cuts as fast (or faster), lasts longer and is easier on your equipment.

Controlled "T" shot and grit may sell for as much as $10 to $20 more per ton, yet we make you this straightforward guarantee: Your cleaning costs (or abrasive costs alone, if you prefer) will be 15% less, regardless of the price you may be paying now for your chilled iron abrasives. Fair enough? The worst that can happen to you on such a test is a 15% saving. Write, wire or phone the nearest Hickman, Williams office.

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Transformation and Mechanical Properties of Ti-Al-Cr Alloys

(Continued from p. 174)

tests, time-temperature-transformation determinations, and age hardening tests.

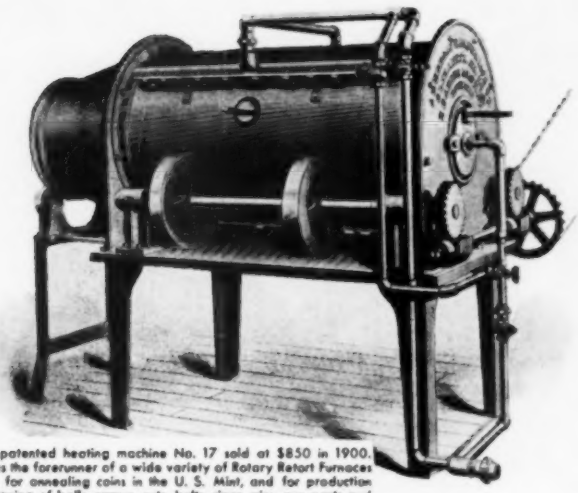
In the end-quench tests, the 2% Cr alloys showed maximum hardness at the quenched end and a decreasing hardness with decreasing cooling rates. In the 4% Cr alloys, the highest hardness was obtained between 2/16 and 4/16 in. from the quenched end. The hardness peak moves farther from the quenched end and to a higher hardness level with increasing aluminum content. The 6% Cr alloys show minimum hardness at the quenched end; the hardness then increases continuously until it levels off at a considerable distance from the quenched end.

Time-temperature - transformation curves were determined for each of the nine alloys. The characteristics common to all curves are the following: a C-curve indicating the start of the transformation of the beta phase; a reversed S-curve which is an estimate of the 95% completion time of the precipitation of alpha from the beta solid solution; and the C-curves indicating the start and completion of the eutectoid decomposition. The eutectoid temperature is approximately 725° C. (1340° F.). Aluminum additions raise the $\beta/\alpha + \beta$ temperature and, for a given aluminum content, increasing chromium additions depress this temperature. The $\beta \rightarrow \alpha + \beta$ transformation proceeds at very high rates. Aluminum additions greatly decrease the time required for the initiation of the eutectoid reaction.

The manner of hardening of these alloys is principally a function of the chromium content. Alloys of low chromium content (2%) attain maximum hardness on quenching from the beta solution temperature range; alloys of intermediate chromium content (4%) are both quench and age hardenable; and alloys of high chromium content (6%) attain maximum hardness on aging of the supersaturated beta solid solution.

For the alloy with 2% Al and 2% Cr, a strength of 106,000 to 168,000 psi. can be obtained, depending on

(Continued on p. 178)



This patented heating machine No. 17 sold at $850 in 1900. It was the forerunner of a wide variety of Rotary Retort Furnaces used for annealing coins in the U. S. Mint, and for production hardening of balls, screws, nuts, bolts, rings, pins, gun parts and many other items.

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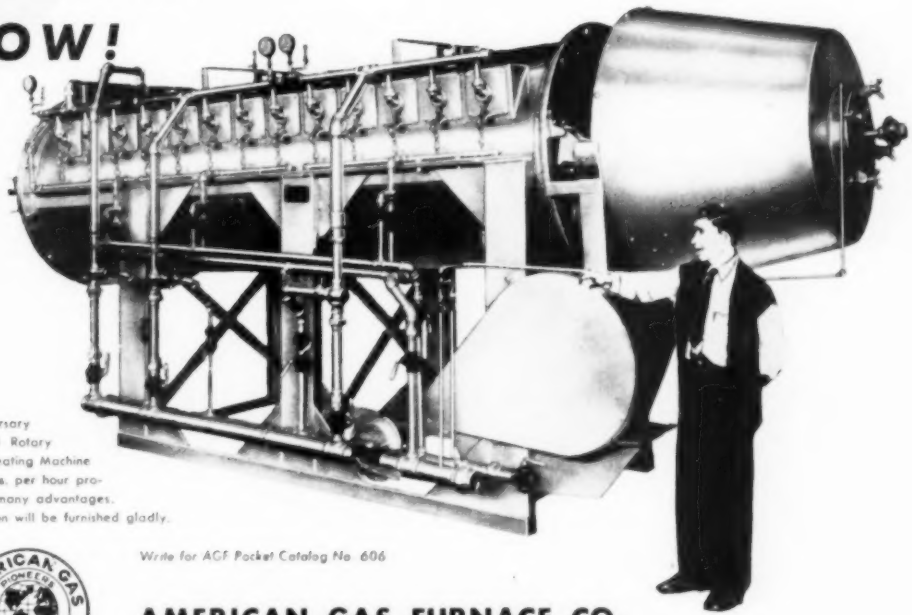
On its 75th Anniversary, American Gas Furnace Co. proudly **salutes these other** PIONEERS of industry who used AGF **Furnaces. To you**—our customers—goes the credit for Seventy-**five years of** AGF Industrial Gas Furnace progress.

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1st Chain Conveyor Heating Machine 1899
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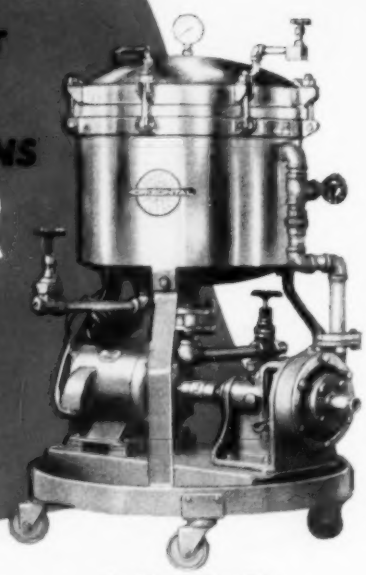
The 75th Anniversary Model No. 139MD Rotary Retort Continuous Heating Machine is a 500 to 1000 lbs. per hour production furnace of many advantages. Complete information will be furnished gladly.

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Sparkler Plating Filter
Model 18-D-6 Alliron
600 G.P.H. Portable

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★ On a horizontal filter plate it is possible to apply a thin pre-coat with about one-third the filter aid, and in one-third the time required for pre-coating a non rigid media or a surface in a vertical position. This saves time and filter aid.

★ With the Sparkler horizontal plate you can apply this thin pre-coat evenly over the entire plate surface and start filtering immediately with less pressure and obtain maximum consistant clarity right from the start up to the end of the cycle.

★ A filter cake on a horizontal plate will not crack, slip or fall off even with varying pressure or a complete shut-down of the filter. No pre-coat renewal is ever required after an interruption in operation.

★ When it is necessary to clean the filter, the Sparkler filter tank can be emptied in a matter of minutes with a minimum of loss of valuable plating solution.

★ Any grade of filter paper from fine to coarse can be used in a Sparkler filter. This makes it ideal for carbon treatment of solutions. Carbon mixed with water in a stand-by tank is circulated through a clean set of filter paper on the plates until a carbon cake is formed. The solution requiring carbon treatment is then circulated through the carbon beds without contaminating the plating tank or a shutdown of plating operations.

★ At the end of the cycle with a Sparkler filter you can blow-down with air and produce a relatively dry cake that can be disposed of in a trash can rather than washing it down the drain with attendant sewer clogging problems.

★ You will find your Sparkler plating filter positive and dependable from a standpoint of uniform high quality filtering and economical in labor and material.

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Transformation and Mechanical Properties of Ti-Al-Cr Alloys

(Continued from p. 176)

the heat treatment. Water quenching results in the highest strength, whereas air cooling from the beta field gives the best combination of strength, ductility, and impact values. In the alloys with 2% Al and 4% Cr, a strength range of 112,000 to 184,000 psi. is obtainable. In general, isothermal heat treatments result in a good combination of strength and ductility. A range of tensile strength from 134,000 to 200,000 psi. is obtained in the 2% Al, 6% Cr alloy. The water quench-age and the isothermal quench-age treatments result in a good combination of properties.

For the alloys studied and heat treatments used, there is a good correlation between tensile strength and Vickers hardness. No correlation was found between ductility and hardness, or between ductility and impact-energy values.

J. W. SPRETNAK

Vacuum-Fusion Analysis of Molybdenum

THE MECHANICAL properties of molybdenum are significantly affected by oxygen contents as low as a few parts per million by weight, and nitrogen contents of the same order of magnitude may have similar effects. In attempting to develop a method of analysis capable of giving results reproducible to within one part per million by weight for both oxygen and nitrogen in molybdenum, a special vacuum-fusion apparatus was constructed. All-glass diffusion pumps and mercury cutoffs were used. Analyses were made by dropping molybdenum samples into a bath of molten iron contained in a graphite crucible.

The furnace section consisted of a glass furnace envelope and a high-speed mercury diffusion pump. In the melting furnace there was a heater assembly consisting of a

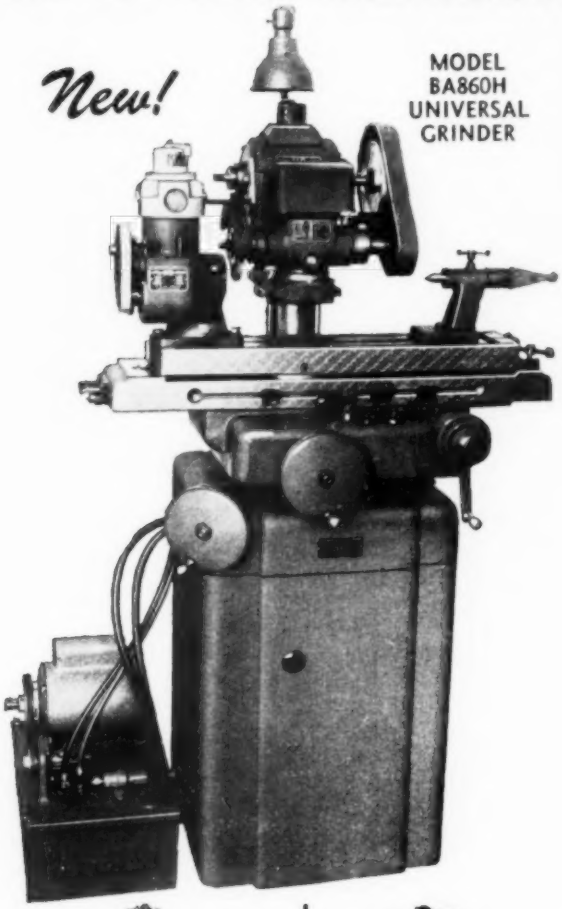
(Continued on p. 180)

★Digest of "Vacuum-Fusion Analysis of Molybdenum", by M. W. Mallett and C. B. Griffith, © 1953 Preprint No. 2.

K. O. Lee Introduces Hydraulic Grinder

New!

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BA860H
UNIVERSAL
GRINDER

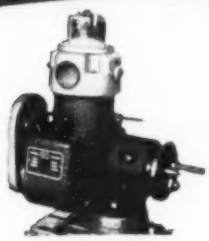


Hydraulic Power Unit For Table Traverse Now Available On All BA800 Series K. O. Lee Grinders

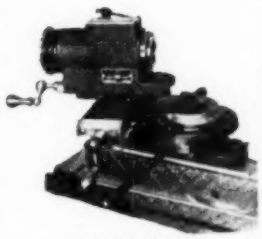
Features . . .

- Pressurized oil flow to traverse table ways. Oil flow is adjustable by needle valve.
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- Adjustable control for dwell desired.
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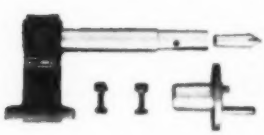


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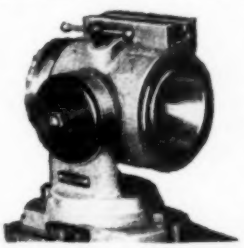


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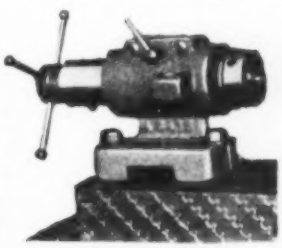
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Vacuum-Fusion Analysis of Molybdenum

(Continued from p. 178)

graphite crucible packed with minus-200-mesh graphite in a clear quartz thimble suspended on a platinum wire. The crucible was heated by induction, using a high-frequency converter of 6-kw. input. The volume of the blank gases was 0.006 cc. per hr. at 1600° C. with an empty crucible, and 0.03 cc. with the crucible containing iron. The blank gases contained 37% CO, 42% N_2, and 25% H_2.

Attempts were made to prepare samples of molybdenum containing known amounts of oxygen in the range of a few parts per million, but without success. Consequently, the problem of determining the absolute accuracy of the vacuum-fusion method was set aside in favor of demonstrating the internal consistency of the method. For preparing samples with a controlled amount of oxygen, rods of vacuum-annealed molybdenum were used into which were added weighed amounts of molybdenum powder having a known oxygen content. The additions were placed into a hole that was drilled in the solid metal, the hole then being plugged with solid vacuum-treated molybdenum. It was found necessary to drill the hole while the specimen was under kerosene in order to prevent oxidation of the molybdenum. Specimens with controlled amounts of nitrogen were prepared by inserting weighed amounts of nitrided molybdenum powder into specimens of commercial molybdenum rod.

It was found that surface preparation of the specimens was very important in controlling the amount of oxygen introduced into the crucible. Two satisfactory methods of surface preparation were: *(a)* abrading with a clean file and then washing with acetone, and *(b)* electropolishing with Coons' solution. Results of the analyses were identical, indicating that both methods clean the surface of oxidation to the same degree. With each method of preparation the oxygen concentration of the surface is about 1.5×10^{-7} g. per sq. cm., according to the results of the analyses. Since this concentration of oxygen was almost invariably found on thoroughly degassed and care-

(Continued on p. 182)



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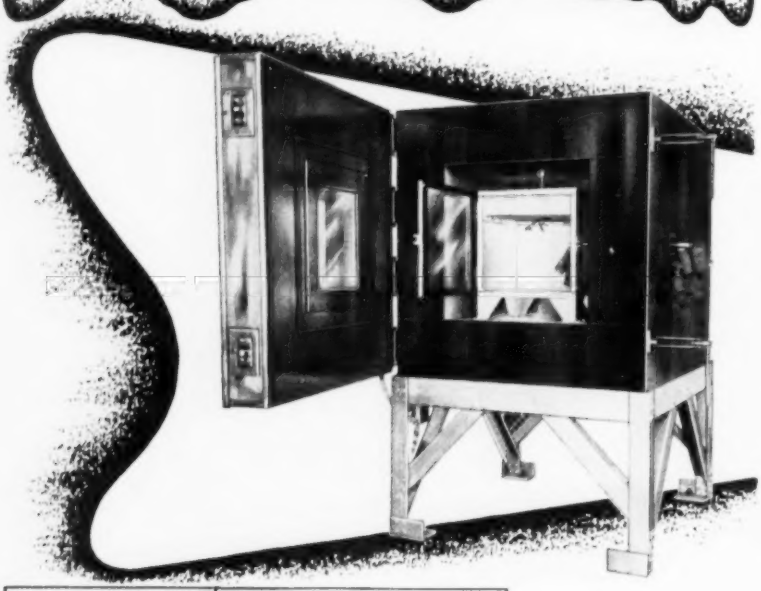
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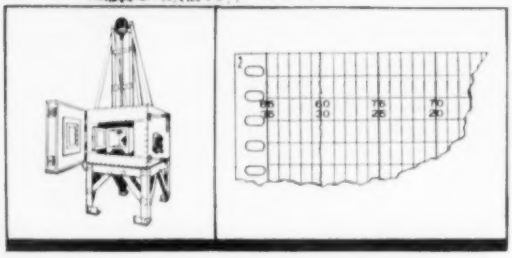
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Vacuum-Fusion Analysis of Molybdenum

(Continued from p. 184)

fully cleaned samples, it appeared that fresh surfaces of molybdenum were superficially oxidized during a few minutes of exposure in air. This indicates that it is advisable to avoid the use of analytical samples having a large specific surface area, such as sheets, chips, and small wires.

With all factors taken into consideration, the work indicated that reproducibility of analyses of experimental samples was 1 part per million by weight for oxygen and nitrogen when the content of these was below about 40 parts per million.

J. L. Gregg

Effect of Nonmartensite Decomposition Products*

The work described in this paper was undertaken in an effort to resolve the differences in the reports of several investigators on the effects of various slack quenched products on notch-impact properties. The steels used in this investigation were A.I.S.I. 5140, 1340 and 2340. These were chosen because they contained only a single alloy and supposedly are similar in end-quench hardenability; however, no end-quench data are shown. The steels were melted in a laboratory-type basic induction furnace and were aluminum-killed.

A series of samples with various types of nonmartensitic decomposition products was produced from each steel by quenching into molten lead at temperatures from 700 to 1300° F. after austenitizing at 1550 to 1575° F., and holding for the time required to produce 10 and 30% of these decomposition products. The samples were oil quenched from the isothermal bath to transform the remaining austenite to martensite. The samples were subsequently tempered at various times and temperatures to Rockwell C-31.5 to 33.5. Oil quenched samples of each grade of steel were also tempered to the same hardness range to produce 100%

(Continued on p. 184)

★Digest of "Effect of Nonmartensite Decomposition Products on the Properties of Quenched and Tempered Steels" by E. F. Bailey, © 1953 Preprint No. 11.

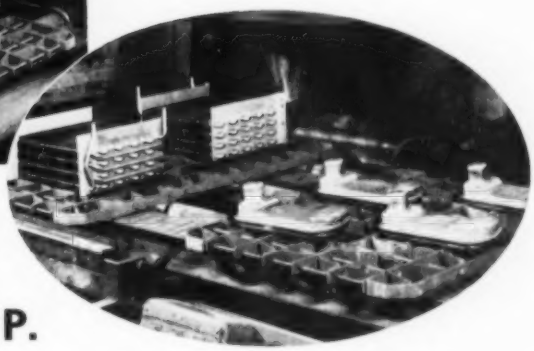
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Effect of Nonmartensite Decomposition Products

(Continued from p. 182)

tempered martensite samples. Standard V-notched charpy bars were used to determine the notch-impact properties, and 0.357-in. diameter tensile bars to determine conventional tensile properties as well as true stress-strain diagrams.

Some decomposition was encountered for the 1340 and 5140 steels on cooling to the isothermal transformation temperature but not for the 2340 steel. This behavior existed in spite of supposedly similar end-quench hardenability.

The presence of 10% nonmartensite decomposition products had little or no effect on notch-bar impact properties or tensile properties; however, 30% nonmartensite products did affect adversely the notch-bar properties of 5140 markedly, 1340 to a lesser degree and 2340 only very slightly. As to tensile properties, the presence of ferrite, formed at 1200 and 1300° F., reduced yield strength and reduction of area when present in the amount of 30%. In general, the more acicular the decomposition product, the less its effect on properties when compared with entirely tempered martensite. In fact, the samples containing 30% of the decomposition products produced at 700° F. appear to have as good, if not slightly superior, impact and tensile properties as the samples having a structure consisting entirely of tempered martensite.

The lower susceptibility to impairment by nonmartensitic products of 2340 steels is attributed to a lesser amount of carbon enrichment of the austenite on separation of the nonmartensite products.

The lower carbon martensites are said to have superior impact properties. The lesser enrichment of the austenite is attributed to the type of decomposition product resulting from the higher alloy content. On this basis the opinion is stated that for the same degree of slack quenching, a higher alloy steel is more desirable than a lean alloy steel.

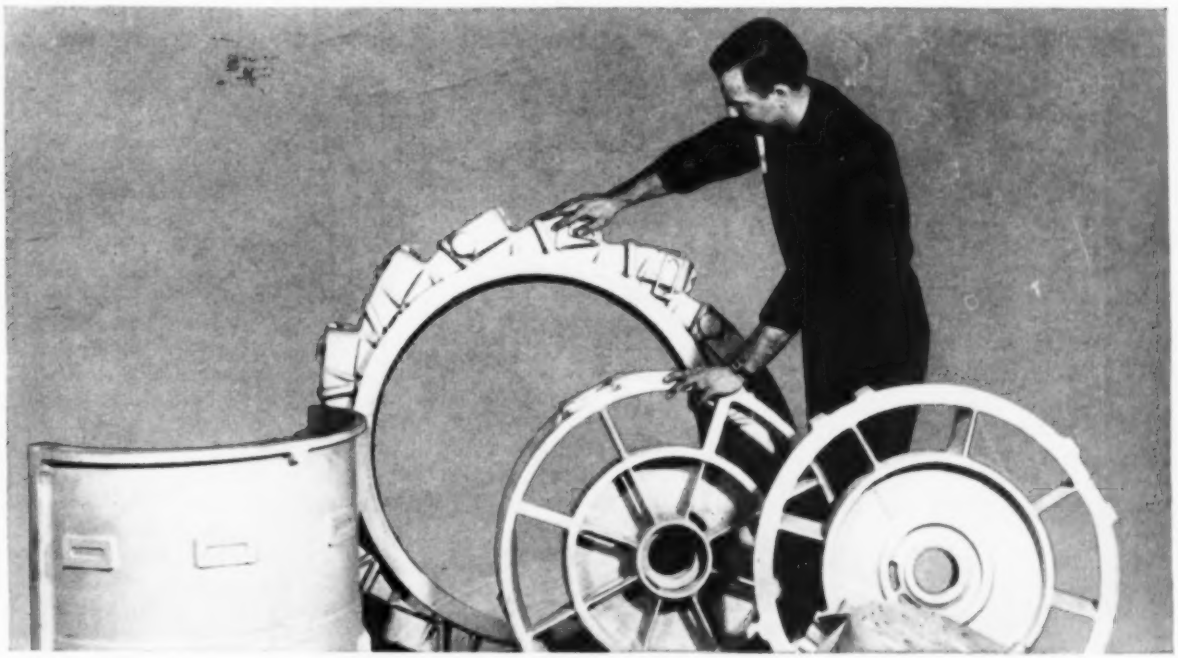
According to this investigation, steels of similar end-quench hardenability can be substituted if not more than 10% nonmartensitic properties can be expected; however, if 30%

(Continued on p. 186)

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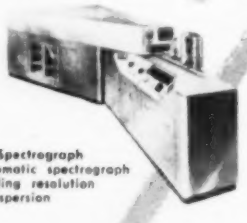
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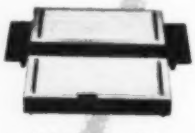
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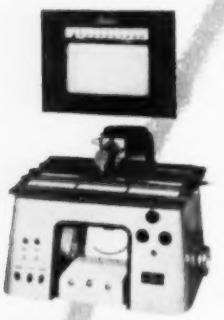
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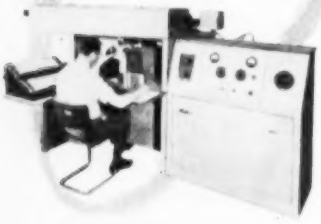
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Effect of Nonmartensite Decomposition Products

(Continued from p. 184)

slack quench products will be produced, hardenability is not a sufficient criterion. The effect of the nonmartensitic properties depends upon the decomposition temperature. The lower temperature decomposition products are not harmful.

A. H. Rauch

The Mechanism of Boron Hardenability in Steels*

In initiating a program of fundamental research on the mechanism of the boron hardenability effect in steels, the authors have formulated a working hypothesis of the boron mechanism to serve as a guide in planning experimental work. This paper is an account of the evolution of the hypothesis, developed from a critical evaluation of existing knowledge of the boron effect and hardenability mechanisms in general.

A consideration of the specific effects of boron in hardenable steels forms the basis for examination of some of the underlying factors in the boron mechanism. The principal effect, of course, is the remarkable increase in hardenability beginning with the introduction of as little as 0.0005% boron in hypo-eutectoid steels. Since the effectiveness of boron is inversely proportional to the carbon content and essentially negligible at the eutectoid carbon content, its effectiveness is also inversely proportional to the amount of pro-eutectoid ferrite characteristic of the carbon content.

Examination of the transformation diagrams of boron steels leads to the following additional observations: First, boron delays the start of transformation at temperatures between Ac_3 and the middle of the bainite range. Second, boron delays the start of transformation to pearlite following the formation of pro-eutectoid ferrite. Third, boron has essentially no effect on the time for completion of transformation.

(Continued on p. 188)

*Digest of "A Hypothesis for the Boron Hardenability Mechanism", by J. W. Spretnak and Rudolph Speiser, © 1953 Preprint No. 20.

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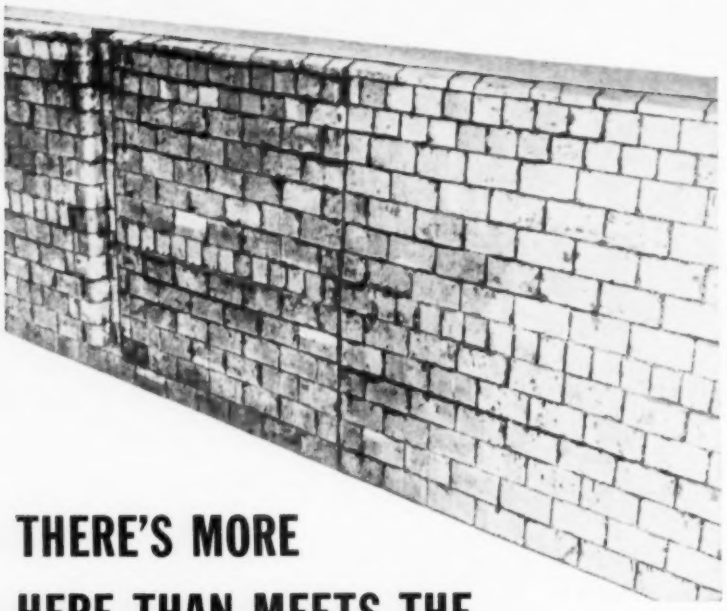
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The Mechanism of Boron Hardenability in Steels

(Continued from p. 186)

With reference to engineering properties, boron is said to impart only a hardenability effect with no significant change in the inherent combination of mechanical properties when quenched to martensite. Reported deleterious effects on impact properties will require some further clarification.

Boron Hypotheses—The hypothesis that the boron hardenability effect is due solely to the occurrence of a film or envelope around the austenite grain is held to be untenable. This position is based on results of previous computations by the authors in which they assumed the existence of a monatomic boron film composed of equiaxed hexagons. They then calculated the extent of adsorption of boron atoms necessary to produce continuous films around the austenite grains. It was found that even with 100% adsorption (all boron atoms at the surface of grains) a continuous film could form only in the smaller grain sizes and then only at relatively high boron contents. Since the degree of adsorption is restricted by the solubility of boron in austenite, it is concluded that continuous film formation is highly unlikely. Nevertheless, adsorption effects involving boron in solid solution appear to be of primary importance regarding certain other aspects of the boron hardenability mechanism.

So important is the formation of pro-eutectoid ferrite to the boron mechanism that it justifies examination in some detail. There are two basic steps in pro-eutectoid ferrite formation: localized depletion of carbon content, and transformation of gamma iron to alpha iron. Consequently, a consideration of the ways in which boron might influence these two steps will assist the clarification of the boron mechanism. For example, it has been postulated that since the ferrite reaction is related to the rate of diffusion of carbon, the presence of boron may cause a decrease in carbon diffusivity. The authors, through a consideration of the relations between boron and carbon atoms in the gamma iron space lattice, show that it is very unlikely that there is any important chemical

(Continued on p. 190)

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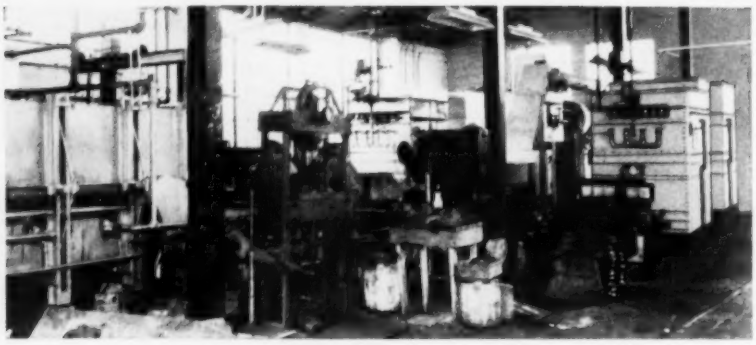
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The Mechanism of Boron Hardenability in Steels

(Starts on p. 186)

interaction between the two. Hence, it is presumed that boron does not have any important effect on the diffusivity of carbon in austenite.

Pro-Eutectoid Ferrite Formation—A detailed consideration of transformation kinetics in boron steel leads to the conclusion that boron has a potent effect in suppressing the formation of pro-eutectoid ferrite and upper bainite. The explanation of these effects in terms of nucleation and shear, as contrasted with nucleation and growth, forms an important aspect of the authors' hypothesis. In this connection they state that there are serious objections to the concept of ferrite formation from austenite as a process of nucleation and growth. These objections are classified and discussed under three headings, as follows:

1. Lattice orientation relationships, in which it is shown that the body-centered cubic decomposition products (pro-eutectoid ferrite, bainite, and martensite) all exhibit definite lattice orientation relationships with the austenite from which they formed. The presence of these orientation relationships is difficult to reconcile using the nucleation and growth mechanism.

2. Kinetics of ferrite formation, in which the argument for ferrite formation as a nucleation and growth process (arising from its time-dependence as contrasted with the time-independence of the nucleation and shear formation of martensite) is refuted. This is accomplished by showing that martensite formation is not necessarily time-independent and hence that kinetics is not a reliable criterion for nucleation and shear transformations.

3. Reversibility of the ferrite transformation, in which it is shown that the gamma-to-alpha or alpha-to-gamma transformation is a transformation *in situ*, and does not cross over into adjoining grains. Such behavior, the authors hold, can be adequately explained only in terms of nucleation and shear.

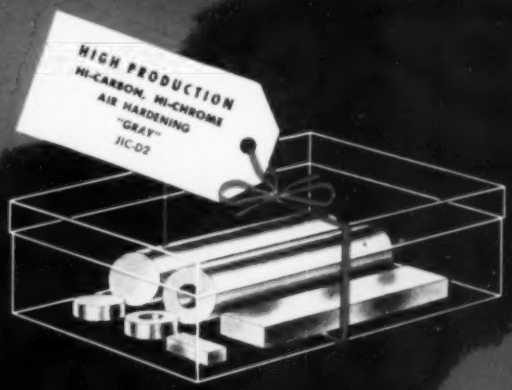
From these arguments the authors conclude that ferrite is formed by nucleation and shear as are bainite and martensite. Pearlite is the only

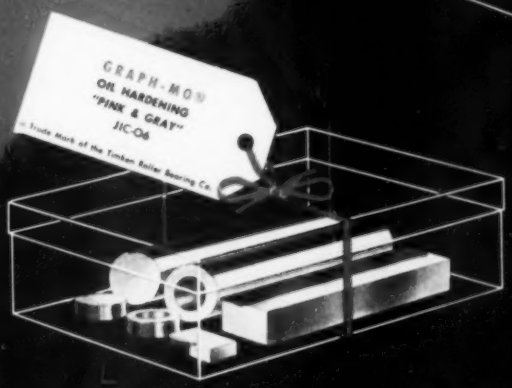
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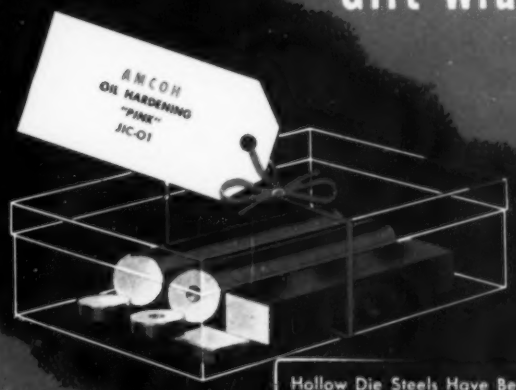
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The Mechanism of Boron Hardenability in Steels

(*Starts on p. 186*)

decomposition product that forms by nucleation and growth. As a general principle, it is stated that a nucleation and growth process takes place when a system passes from a disordered state to a more highly ordered state (such as the transformation from the liquid state to the solid state, or precipitation of a compound from a solid solution). On the other hand, shear transformations (allotropic transformations) involve cooperative movement of many atoms from one ordered state to another ordered state.

The Boron Hardenability Effect—In formulating a working hypothesis for the mechanism of the boron hardenability effect, two factors stand out as being basically important. These are that boron acts principally in suppressing the formation of pro-eutectoid ferrite and upper bainite, and that the fundamental mechanism is a shear mechanism. It follows then that the boron effect is a solid solution effect arising from the exceptionally high strain energy peaks in the vicinity of the boron atoms in the austenite space lattice. In general, introducing an interstitial solute atom into the iron lattice introduces strain energy, the magnitude of which is proportional to the difference in the size of the solute atom and the size of the interstitial hole. It is postulated that these localized energy peaks increase the resistance to the fundamental shear mechanism in the ferrite reaction and hence retard the gamma-to-alpha transformation.

This proposed boron mechanism has interesting engineering ramifications. The effect is principally a delay in the start of transformation. Boron, then, should be an effective alloy substitute in engineering parts of such geometry that all points cool at rates in excess of the critical cooling rate. However, in slack quenched parts, the hardness will fall off more rapidly in the interior of the part, and in these boron is expected to be inferior to the substitutional solute atoms such as manganese, chromium, and molybdenum which also affect the transformation. Also, boron would be expected to be ineffective

(*Continued on p. 194*)



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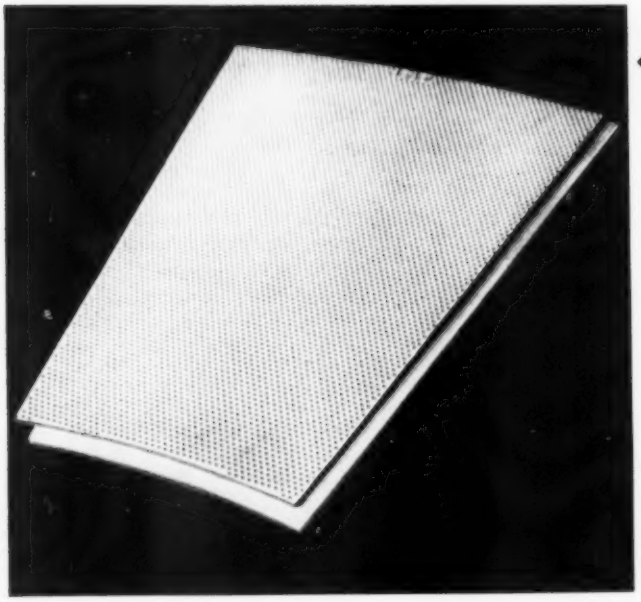
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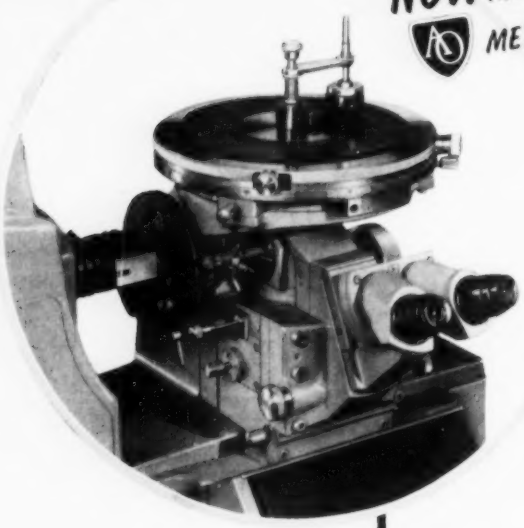
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The Mechanism of Boron Hardenability in Steels

(Starts on p. 186)

in carburized cases with carbon contents in excess of the eutectoid composition.

Since, according to the authors' hypothesis, the effect of boron in suppressing the shear transformation of gamma iron to alpha iron depends upon the exceptionally high strain energy peaks associated with the boron atoms in solid solution, some comparative calculations were made on strain energy effects of carbon, nitrogen and boron dissolved interstitially in gamma iron. Results of these calculations, based on relations between lattice parameters and concentration and diameters of interstitial solute atoms, indicate that the ratios of the strain energy peaks for carbon, nitrogen, boron are on the order of 1:2:10. Furthermore, when translated into hardenability effectiveness ratios (by computing some product of the strain-energy peaks and the volume of the distorted lattice) these figures become 1:3:50.

Summary—Following are salient points from the authors' summary, listing the essential features of their hypothesis.

1. The effect of boron in steels is the retardation of the formation of pro-eutectoid ferrite and upper bainite. Boron does not retard the formation of pearlite.

2. Adsorption effects of boron at austenite grain boundaries are very likely important factors in the hardenability effect.

3. Important chemical interactions between boron and carbon in austenite are unlikely.

4. It is concluded that pro-eutectoid ferrite forms from austenite by a shear mechanism.

5. A shear transformation occurs by a cooperative movement of several atoms whereas in diffusion, the atoms change their positions at random and independently.

6. As a general principle, a nucleation and growth process takes place when a system passes from a disordered state to a more highly ordered state; shear transformations involve cooperative movement of atoms from one ordered state to another ordered state.

7. The boron hardenability effect

(Continued on p. 196)

Tool Steel Topics

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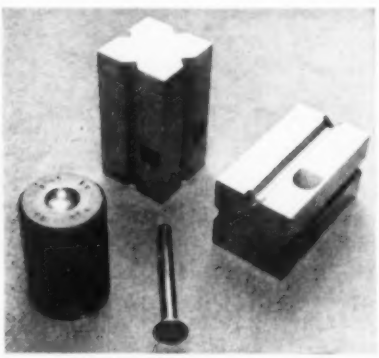
PENCIL SLIPPED . . . DIES BROKE

One of our customers reported his cold-heading dies were cracking and spalling. The spalled areas appeared to be the result of the hard case upsetting into the softer core.

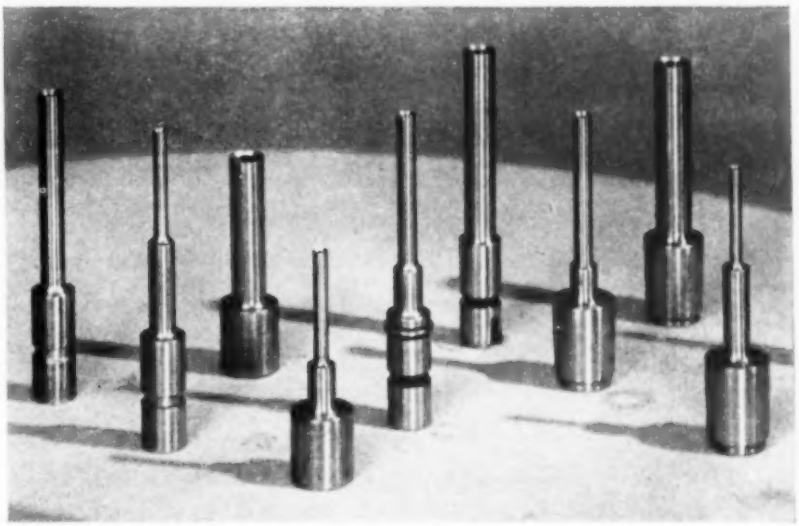
Our metallurgical contact man who visited the customer's plant couldn't find anything out of order, until he happened to read over an order the customer had entered for the steel. Then the light began to dawn.

The answer? The customer had failed to specify "cold-heading die quality" on the order. There's quite a difference between ordering "carbon tool steel" and "cold-heading die quality steel."

It's the difference between a tool steel that's processed for doing a fine job on severe cold-heading and steel that just isn't suitable for this type of special application.



The gripper and header dies shown above, made of Bethlehem XX Cold-Heading Die Steel, have the right combination of hard surface and tough core for cold-heading thousands of steel bolts each day.



"Even the roughest kind of service in binderies and printshops won't break paper drills when they're made of Omega tool steel," says William Gynther of Bent and Gynther, Portland, Ore.

OMEGA HELPS TO STOP BREAKAGE OF PAPER DRILLS

Drilling holes through paper may sound easy, but it isn't. Printers who do much paper drilling will tell you that the drills often break and bend.

The other day we were given quite a fill-in on the subject by William Gynther, one of the owners of Bent and Gynther, Portland, Ore., suppliers of drills to the printing trade. Mr. Gynther told how he once noticed four broken drills on the desk of a prospective buyer. He made a wager that *his* drills wouldn't break, even though this print-shop apparently gave the drills pretty severe treatment. The printer took him up — and hasn't broken a drill in some years.

The success of the "B and G" drills is attributed by Mr. Gynther to the unique taper inside the drill and to the grade of tool steel (Bethlehem's Omega). Omega is our silico-manganese grade of shock-resisting steel, and while it is intended mainly for cold-battering tools where terrific shock must be absorbed, it appears to have the ideal hardening properties for these paper drills, together with plenty of the toughness required to withstand stress and strain.



BETHLEHEM TOOL STEEL ENGINEER SAYS:

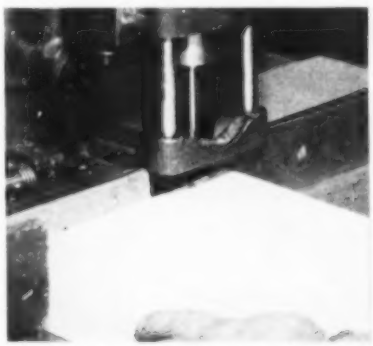
Always temper immediately after hardening

It's always risky to delay or to omit tempering immediately after a hardened tool cools following the quench. With a liquid-quenched steel always get the tool into the tempering furnace as soon as it cools down to about 150 to 200 F.; an air-hardening steel should cool to 150 F.

Some heat-treaters spit on a tool — if there's no sizzle, it's cool enough to temper. You can also use a contact pyrometer or other indicators to get a more accurate check on the temperature of freshly quenched tools.

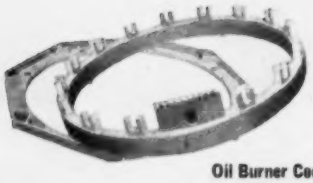
If you delay the temper — to check hardness or for some other reason — you're running the risk of permitting stresses to build up. And these stresses may crack the tool in half, even before it reaches the tempering furnace. Of course, such failures don't always occur if this precaution is ignored.

Some people just can't be convinced that it's risky to delay tempering after the tool cools following the quench. But there's no way to predict just when it may happen, so why take the risk?



Boring holes through a stack of paper doesn't sound like a tough job, but there's a lot of stress on these hollow drills which causes frequent breakage — unless they're made of the right steel.

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The Mechanism of Boron Hardenability in Steels

(Starts on p. 186)

is a solid solution effect. The high strain-energy peaks in the austenite lattice associated with the boron atoms are effective in retarding the shear transformation to ferrite.

8. Fundamentally, the elements carbon, nitrogen and boron affect hardenability by the same mechanism, but boron is considerably more effective than carbon and nitrogen.

9. The strain-energy peaks associated with carbon, nitrogen and boron atoms were calculated and found to be in the ratio of 1:2:10.

10. Corresponding hardenability effectiveness ratios for carbon, nitrogen and boron were found to be in the ratio of 1:3:50.

W. W. AUSTIN

Influence of Boron on Temper Embrittlement *

THERE has been speculation regarding the effects of small amounts of boron, used to increase hardenability, on temper brittleness, and reports of previous investigations have not been in complete agreement in their findings. This report covers the investigation of the effects of 0.0034% boron on the susceptibility to temper brittleness in a 0.26% carbon, 1.65% manganese steel. The influence of time, tempering temperature and grain size on transition temperature was investigated, and isothermal embrittlement diagrams were developed for this steel.

Temper embrittlement is divided into two types, reversible and irreversible. Irreversible temper embrittlement is described as that which occurs at progressively longer times at high tempering temperatures and is attributed to ferrite grain growth. Boron was found to have no effect on this type.

The reversible temper embrittlement is said to comprise grain-boundary embrittlement which develops most rapidly at about 975° F., and which can be avoided by proper heat treatment. Boron apparently

(Continued on p. 198)

*Digest of "The Effect of Boron on Notch Toughness and Temper Embrittlement", by A. E. Powers and R. B. Carlson, © 1953 Preprint 21.





This worker is loading rocket motor bodies on the conveyor to the mechanized neutral salt bath. The fixture holding the parts is made of Inconel, weighs 20 lbs. Fixtures were designed and fabricated by The Brown-Hutchinson Iron Works, Detroit, who did the development work. They have given a service life of 4,300 hours.

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A major auto producer, engaged in arms manufacturing, keeps production flowing in a straight line operation. Here rocket motor bodies for 3.5 inch bazooka shells are sent through a mechanized neutral salt bath to be heat treated for additional strength and shock resistance. The units are placed on Inconel® fixtures, fabricated by The Brown-Hutchinson Iron Works, and sent through a cycle ranging from processing at 1550° F. down to hot water rinses.

The fixtures gave excellent service under these conditions. They were still serviceable after 4,300 work hours.

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Influence of Boron on Temper Embrittlement

(Continued from p. 196)

does increase susceptibility to this type of embrittlement. The authors, however, do not consider the magnitude of the effect sufficient to warrant condemnation of the commercial boron steels.

It was thought that the coarser grain size of boron steel might account for its greater susceptibility to temper embrittlement. However, austenitizing the untreated steel to produce approximately the same grain size as the boron steel failed to increase its transition temperature to any great extent. A. H. Rayon

Strain Aging and Rheotropic Recovery*

In several earlier papers, the author and his colleagues have investigated the improvement in the ductility of steel and zinc at and below their transition ranges as a result of prestraining at temperatures above the transition ranges. The brittleness which may be removed by such prestrain has been termed rheotropic brittleness, while its partial or complete elimination is called rheotropic recovery.

A question that has frequently arisen regarding steels in particular is the influence of strain aging (which may occur during or following prestraining) on the low-temperature ductility. In his previous work, the author had maintained substantially constant holding times (at room temperature) between prestraining and testing. This tends to eliminate variations in the amount of strain aging from one test to another. In the present work, however, an attempt is made to assess the effect of varying the amount of strain aging. This might have been accomplished by variation of time of aging at a given temperature, but the author has alternately chosen to vary the aging temperature with the tacit assumption that the amount of strain aging for a constant aging time will increase up to some temperature and

(Continued on p. 200)

*Digest of "Strain Aging Behavior of Rheotropically Embrittled Steel", by E. J. Ripling. © 1953 Preprint No. 35.

H. J.
Here's a really fantastic letter!
P.W.

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Dear Sirs:

We called upon the services of your lubrication engineer, Mr. A. J. Blake, in reference to a serious staining condition which we were having with our soluble oil. He analyzed this condition and recommended one of your Chillo Oils. This oil was tried and the rust condition eliminated to our satisfaction.

To our surprise on his next visit he was dissatisfied with our tool life and suggested we use a soluble oil called "Chillo A". Now not only do we have clean machines, but tool life has been increased 20%! While in our plant he asked permission to "look around", which, of course, was granted.

We were using a tapping compound with precision ground taps in order to hold to close tolerances. We did not consider tap breakage excessive but the removal of broken taps was sometimes rather expensive. He recommended we use "Chillo 10Z". Then came the surprise of our lives! With Chillo 10Z we have gone to commercial ground taps (a 300% savings) and can still hold our same tolerances, with a sharper thread, increasing tap life a minimum of 20% plus eliminating expensive removal of broken taps!

We also have a production stamping job which required a new set of dies every month. On his recommendation we tried Chillo 10Z with these dies. Now our die life has increased to at least two months...a saving in die life of 100%, disregarding labor costs. We also increased production 200% per die sharpening!

We tried the same oil on our broaching operation and found that instead of making two cuts we can get the same results now with one. We were using one of your competitors' hydraulic oils and you told us it was a "good oil" and would give us satisfactory performance. BUT, GENTLEMEN, WITH THE EXCELLENT SERVICE YOU HAVE GIVEN, PLUS THE TIME AND MONEY SAVED, YOU MAY REST ASSURED THAT ALL OF OUR LUBRICATING REQUIREMENTS WILL BE PURCHASED FROM YOU.

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Strain Aging and Rheotropic Recovery

(Continued from p. 198)

then decrease as overaging occurs. In this investigation, an aging time of 1 hr. over a range of 70 to 700° F., plus 2.5 hr. of holding at room temperature was employed between prestraining and testing.

The steel studied was S.A.E. 1340 which had been quenched and tempered at either 600 or 700° F. Following various amounts of prestrain and the selected aging treatment, the 600° F. series of specimens was tested at −210° F., and the 700° F. series at −321° F. These temperatures are just at the lower end of the transition ranges of the steel in these two conditions, where a maximum effect is to be expected.

As the aging temperature is increased from 70 to 400° F., where a maximum aging effect would be anticipated for 1 hr. of aging, the prestrain required to produce the maximum rheotropic recovery increases from approximately 0.25 to 0.31 in each series, and the maximum retained ductility decreases by half. As the aging temperature rises higher, both these trends are reversed.

The standards to which all results are compared are the tests with an aging period of 3.5 hr. at room temperature. Strain aging is not absent for this treatment, but it is relatively limited. Other tests show that more aging occurs during the tests with elevated aging temperatures, and thus it may be concluded that additional strain aging above that present in the standard tests caused the pronounced decreases in rheotropic recovery which have been mentioned.

The problem still remains, however, of determining the rheotropic recovery possible for a steel which has undergone no strain aging whatever. To accomplish this, it is necessary to employ a temperature for prestraining at which it has been demonstrated that no strain aging occurs. Comparison might then be made of the results of such tests and of those in which a period of aging at elevated temperatures is included to ascertain the complete effect of strain aging.

Two subsidiary conclusions have been drawn from the data in this paper. First, that the influence of

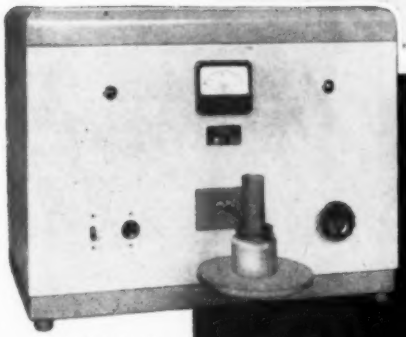
(Continued on p. 202)

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Strain Aging and Rheotropic Recovery

(Continued from p. 200)

strain aging upon ductility is much greater at temperatures below the transition range than at those above it. Second, based on the observation that there is only a shallow maximum of the curve of strain for maximum rheotropic recovery versus aging temperature, and on an analysis of the influence of transition temperature upon such strain, the author concludes that strain aging has only a mild influence upon the transition temperature. R. Lowrie

Supercooling and Solidification*

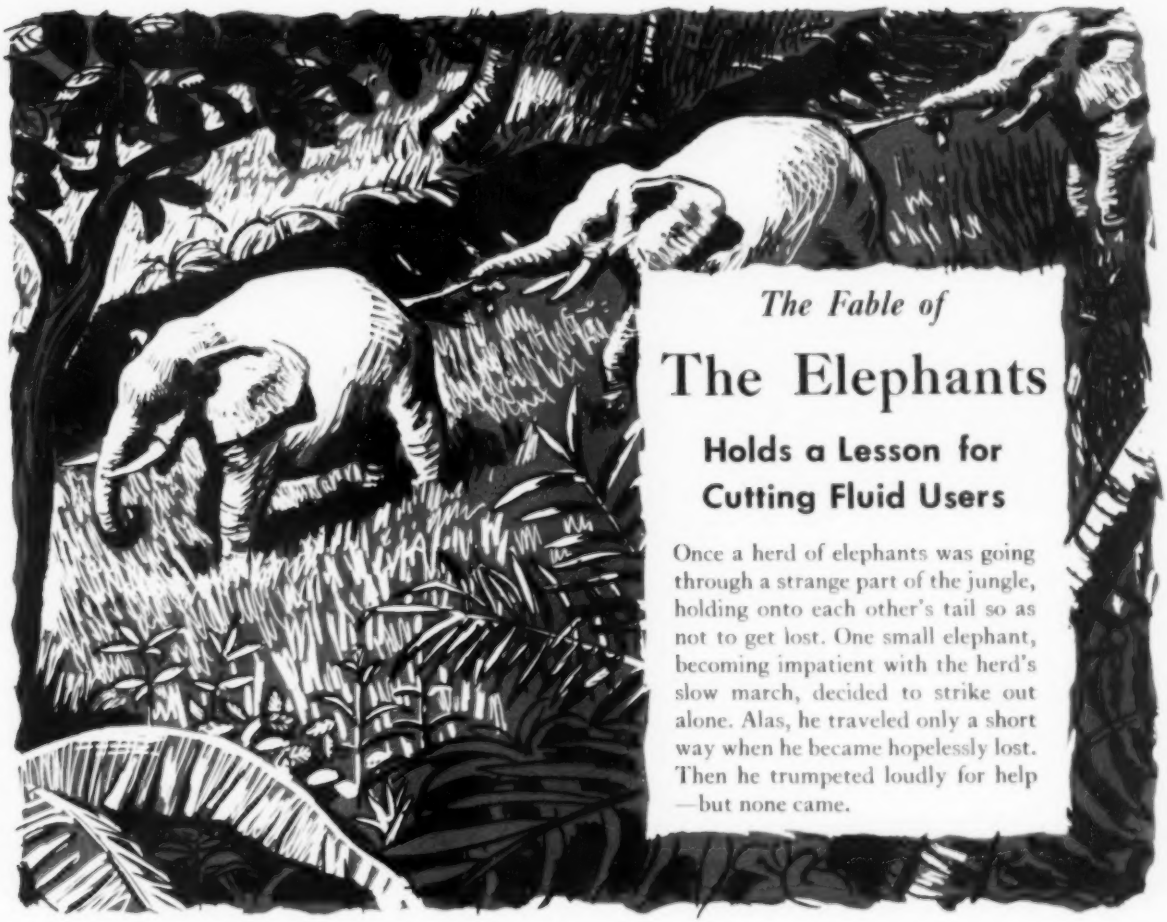
THE AUTHORS give an explanation for certain features of ingot structure that have not previously been explained satisfactorily.

The extent of supercooling existing in the liquid phase, defined as the difference between the actual temperature of the liquid and the temperature at which the solid and liquid are in equilibrium (the liquidus temperature for an alloy), is the key factor. The (circular) interface between the solid and liquid portion of a cylindrical ingot, considered to be a smooth surface initially, can be at the equilibrium (liquidus) temperature only if it is stationary. If the interface is moving there must be supercooling, and the gradient of supercooling will determine the method by which the surface advances into the liquid. The growth of a solid crystal into the liquid will be retarded if the amount of supercooling in the liquid decreases as the growth increases, and will be accelerated if the amount of supercooling increases as the growth increases.

If the liquid away from the interface is supercooled less than the material at the interface, the entire interface will advance at the same speed and the growth of any favorably oriented grain will be retarded if it tries to move ahead of the interface, so the interface should remain plane. On the other hand, if the liquid away from the interface is

(Continued on p. 204)

*Digest of "Supercooling and Dendritic Freezing in Alloys", by W. C. Winegard and B. Chalmers, © 1953 Preprint No. 16.



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Holds a Lesson for Cutting Fluid Users

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Supercooling and Solidification

(Continued from p. 202)

supercooled more than that at the interface, the interface will divide into widely spaced fast-growing dendrites separated by regions which grow at a much slower speed, this being determined by the rate at which the latent heat of fusion is conducted away through the solid material.

In ingots of pure metals the liquid metal in the interior cannot supercool once the surface is frozen, so dendritic growth is not observed.

In solid solution alloys the liquid near the advancing interface is enriched in solute. Even though diffusion tends to decrease this concentration differential, the equilibrium solidification temperature (liquidus) of this region will be somewhat lower than that of the remainder of the liquid. By the removal of heat through this small zone of lower solidifying liquid, the entire mass of liquid can become supercooled until dendritic freezing becomes possible. This is called "constitutional supercooling". The solidification of an ingot of a solid solution alloy, therefore, takes place through three stages: (*a*) a surface chill zone of very rapid cooling caused by the liquid coming in contact with the relatively cool wall of the mold; (*b*) a columnar intermediate zone, caused by the growth of the most favorably oriented crystals of the chill zone, in which no new crystals can be nucleated until the liquid becomes sufficiently supercooled; (*c*) a central equiaxed zone in which further nucleation occurs because of marked constitutional supercooling—that is, supercooling becomes possible because of the variation in composition caused by freezing.

The "pasty condition" sometimes found in a solidifying liquid cannot occur under equilibrium conditions but only can be found when supercooling has been produced and has resulted in the nucleation and growth of dendrites which then have grown until there is no longer any supercooling and the region consists of a mass of dendrites with liquid between. This condition can, but need not, occur in the solidification of a solid solution alloy.

C. H. SAMANS

Recrystallization in Mo Related to Mechanical Properties*

MOLYBDENUM can be either very ductile or very brittle at room temperature, depending on the microstructure developed by the prior mechanical and thermal treatments. This applies to wrought metal that has been compacted by casting or sintering. Ingots of cast molybdenum have a coarse, columnar grain structure similar to that observed in other cast metals. Sintered ingots, however, have a fine equiaxed grain structure. With cast molybdenum the columnar structure can be eliminated by hot working such as forging, rolling or extrusion. Once the coarse, columnar structure is eliminated, additional grain refinement is obtained only by recrystallization following cold working. A hot breakdown operation is unnecessary for sintered ingots because they have a fine structure as consolidated.

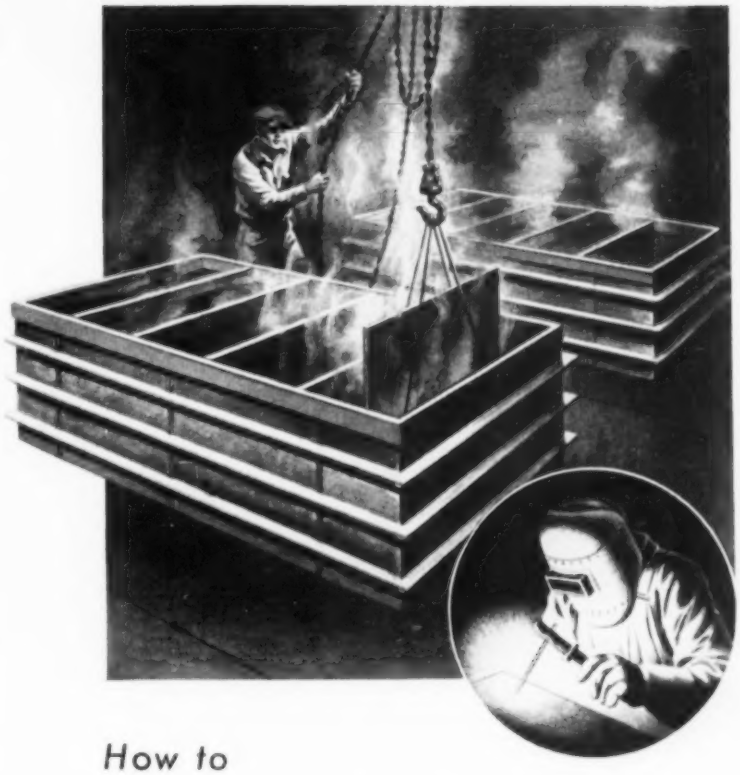
Molybdenum is either ductile or brittle at room temperature because there is a transformation from ductile to brittle behavior in the neighborhood of room temperature. This transformation temperature increases with increased grain size, and the fine-grained metal is generally ductile at room temperature while the coarse-grained material is brittle.

Either fine-grained recrystallized molybdenum or coarse-grained metal may be obtained by cold working and annealing, the fine-grained material showing ductile behavior and the coarse-grained material brittle behavior. Cold working of molybdenum may consist of working at a temperature as high as 2000° F., but below that temperature at which the metal will tend to recrystallize on working. This is shown by the microstructures of sintered metal reduced 75% in cross section by rolling at temperatures of 1470, 1740, 2000 and 2370° F. At the three lower temperatures, an elongated structure of considerable fineness and uniformity was obtained, but at 2370° F. a very coarse and nonuniform microstructure resulted.

Specimens of both cast and

(Continued on p. 206)

★Digest of "Recrystallization Data Applied to Control of the Mechanical Properties of Molybdenum", by J. H. Bechtold, © 1953 Preprint No. 15.



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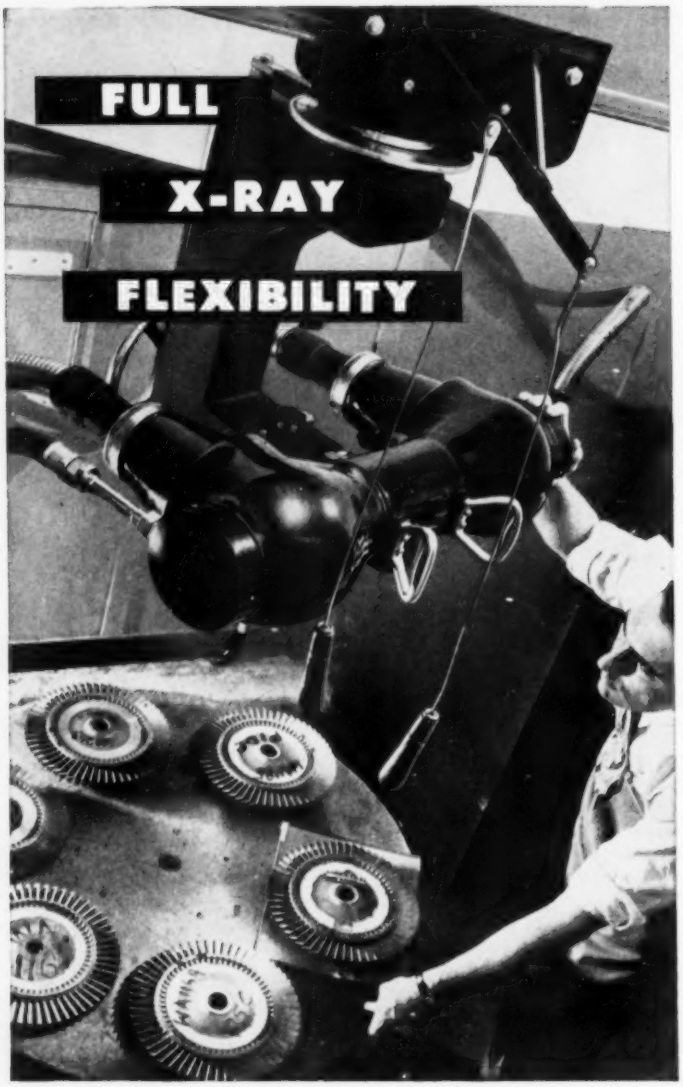
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Recrystallization in Mo Related to Mechanical Properties

(Continued from p. 205)

sintered molybdenum were cold worked to different reductions of area, and were then annealed at a series of temperatures. Grain-size measurements and tensile tests were made with these specimens. By annealing at the proper temperature, a recrystallized structure of fine grain could be obtained. The fine-grained specimens were ductile at room temperature whereas those having coarse grain were brittle. Tensile tests at selected temperatures in the range 103 to 390° F. proved that this was a result of the shift in transformation temperature, the transformation temperature being slightly below room temperature for fine-grained metal and above room temperature for coarse-grained. An increase in grain size from 1700 to 100 grains per sq.cm. raised the ductile-to-brittle transformation about 210°.

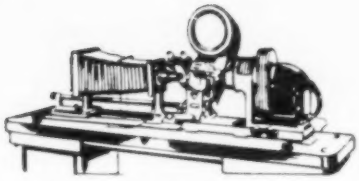
The sintered molybdenum could be annealed at a higher temperature than the cast material without producing large grains, probably because the oxides in the former inhibit grain growth. J. L. Gregg

Lower Fatigue Properties Attributed to Elongated Inclusions*

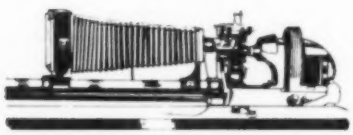
THIS PAPER states that the marked anisotropy due to the presence of elongated inclusions lowers the fatigue properties of steel. In bend tests of two commercial steels, the transverse fatigue limit was found to be 52 and 68% of their longitudinal fatigue limit. In a vacuum-melted steel, the transverse fatigue limit was found to be 86% of the longitudinal limit. This improvement was ascribed to the absence of nonmetallic inclusions. The steels used in this investigation were S.A.E. 4340, quenched and tempered to Rockwell C-27 to 29, and of normal cleanliness. One of the steels was purchased as "aircraft quality" while the other was made in the basic electric furnace.

(Continued on p. 208)

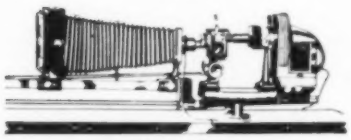
*Digest of "The Effect of Inclusions on the Fatigue Strength of S.A.E. 4340 Steel", by J. T. Ranson, ⊕ 1953 Preprint No. 12.



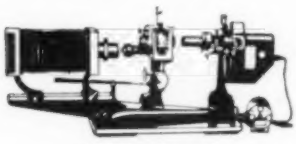
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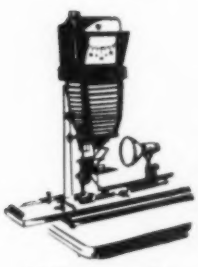
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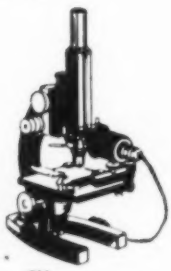
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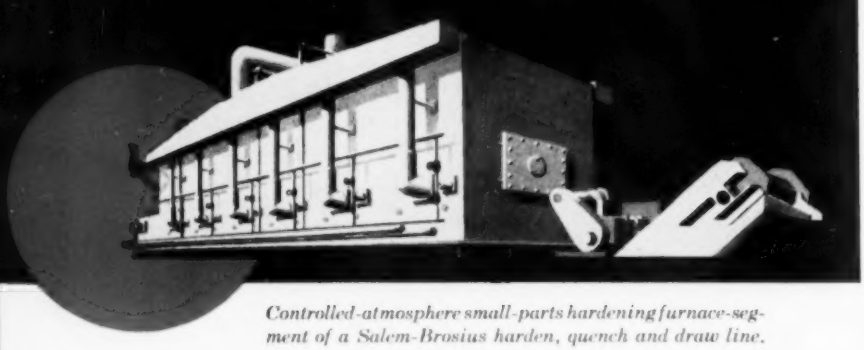
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Lower Fatigue Properties Attributed to Elongated Inclusions

(Continued from p. 206)

Evidence of the deleterious effects of elongated inclusion is indicated by the fact that fatigue cracks originated at inclusions. In the repeated bending test of transverse specimens, the crack emanated from elongated inclusions. In torsion testing, cracks originated when inclusions were elongated either normal to the direction of principal tensile stress or parallel to the direction of maximum shear stress.

Some anisotropy was found in the vacuum-melted steels, in spite of the fact that cracks did not originate at inclusions. This is attributed to directionality in properties resulting from banding.

The author recognizes that complete elimination of inclusions is impractical, perhaps impossible. The superior properties of vacuum-melted steel are held up as an ideal, however, which the steelmaker should try to achieve. Changing the shape of inclusions from elongated to spherical is suggested as a possible method of reducing anisotropy.

A. H. RAUCH

Gamma Loop in Fe-V and Fe-V-Ti Systems*

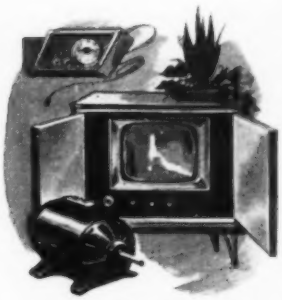
PREVIOUS WORK on the gamma loop in the Fe-V system has produced conflicting results. The limit of this loop has been reported in the literature to be as low as 1.1% V and as high as 2.5% V. The presence of carbon in the alloys can lead to tying up of vanadium as a stable carbide. This investigation was undertaken to establish the Fe-V gamma loop and to determine the limit of the gamma-iron region in the Fe-V-Ti system.

Alloys for this study were produced from Armco iron, sponge titanium, and high-purity vanadium metal. The alloys were melted in an alundum crucible in a mall induction furnace. In most instances the melts were deoxidized with aluminum. The transformation temperatures

(Continued on p. 210)

*Digest of "Gamma Loop Studies in the Iron-Vanadium and the Iron-Vanadium-Titanium Systems," by William R. Lucas and W. P. Fishel, 1953 Preprint No. 30.



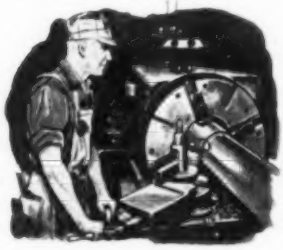


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Gamma Loop in Fe-V and Fe-V-Ti Systems

(Continued from p. 208)

were determined from the discontinuities in the dilation-temperature curves resulting from the allotropic transformation. The dilation specimens were 3½ in. long and ¾ in. diameter. Thermocouple holes were provided in each end for temperature measurements.

The dilation specimen rested on the bottom of a McDanel combustion tube which served as a dilation tube. The dilation of the specimen was transmitted to a dial gage reading to 0.0001 in. by means of a zircon rod. All tests were performed in an argon atmosphere. In the study of the Fe-V system, the dilation specimens were not at the same temperature throughout the entire length, the bottom being 10 to 25° C. (50 to 75° F.) hotter than the top. As the α-γ region is approached during heating, the high temperature end begins to transform first. The transformation then proceeds up the specimen until the critical temperature is reached at the cooler end. The beginning of the transformation corresponds to the temperature in the bottom end of the specimen at which expansion ceases or a break occurs in the dilation curve, and the end of transformation is indicated by the temperature at the top of the specimen at which expansion again takes place. A cooling rate of 3° C. (5° F.) per min. was found to be satisfactory. Isothermal techniques were employed in some instances to establish equilibrium. In the Fe-V-Ti studies, the thermal gradient in the specimen was eliminated.

Seventeen alloy compositions were used in the Fe-V studies. Duplicate runs were found to agree within 3° C. A minimum point in the gamma loop was found at approximately 0.2% V and 89° C. (192° F). The limit of the gamma loop was determined as being between 1.47 and 1.62% V (nominal value of 1.5% V).

Twenty-three alloy compositions were used to establish the limit of the α-γ field in the Fe-V-Ti system. It was found that Ti and V are not additive in their influence on the gamma loop. The amount of vanadium required to produce a closed gamma loop is reduced significantly

(Continued on p. 212)

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Gamma Loop in Fe-V and Fe-V-Ti Systems

(Continued from p. 210)

only with titanium contents exceeding 0.2%. Also, the amount of titanium required to close the loop is significantly reduced only with vanadium contents in excess of 0.2%. This effect may be related to the minimum points at 0.2% in both the Fe-V and Fe-Ti systems. Using the present data along with prior data on the gamma loop in the Fe-Ti system by Roe and Fishel ("Gamma Loop Studies in the Iron-Titanium, Iron-Chromium, and Iron-Titanium-Chromium Systems", Midwinter Meeting of ASM, Pittsburgh, 1952) a three-dimensional model of the gamma loop region in the Fe-V-Ti system was constructed and a photograph of this model is presented in the paper. J. W. SPRETNAK

Grain Coarsening in High Speed Steel*

A NEW LOOK is taken at the phenomenon of the severe grain coarsening ("fishscale" fracture) which occurs in high speed steel when it is rehardened without an intermediate anneal. The results of experiments that were conducted tend to invalidate the popular conception that grain growth is caused largely by strains introduced during the first quenching treatment.

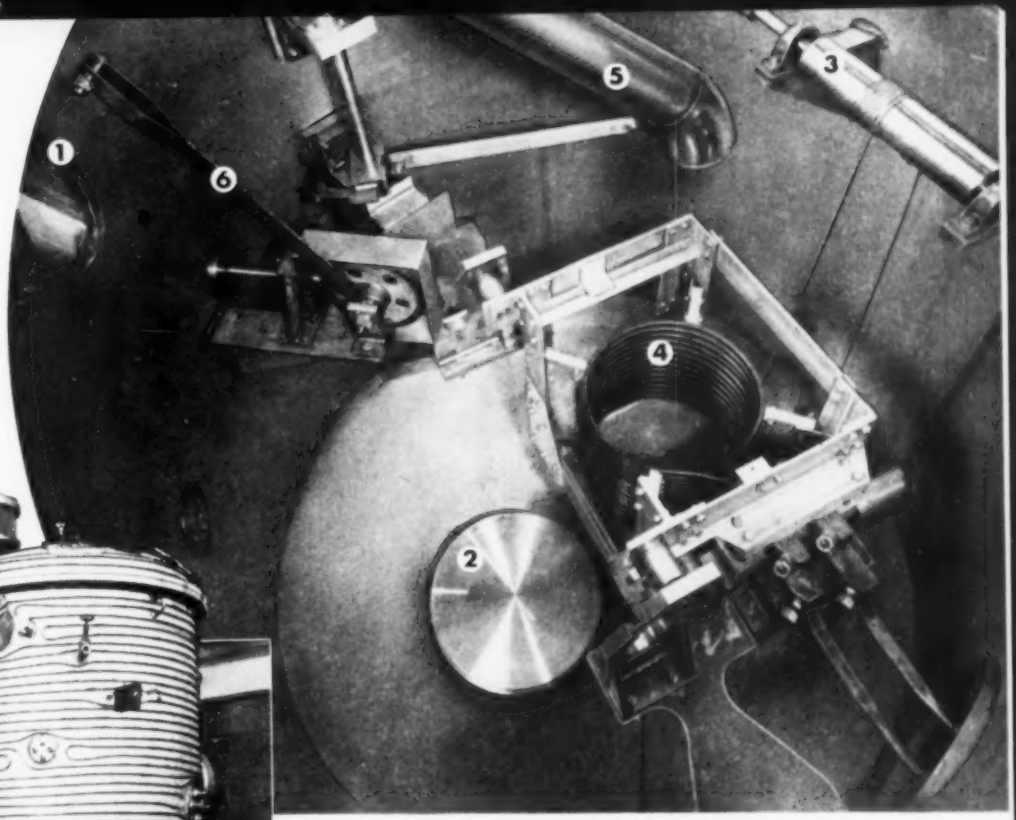
The occurrence of grain growth on double hardening is established as a sudden and discontinuous effect occurring abruptly at some critical temperature which is dependent upon the original hardening temperature. Experiments with 18-4-1 high speed steel show that when the original austenitizing temperature was below 1900° F., no grain coarsening or fishscale fracture occurred on rehardening at any temperature. When the original austenitizing temperature was above 2000° F., the coarsening temperature was found to increase with an increase in prequenching temperature, but always to be somewhat below the original quenching temperature. When the prequenching temperature was within the range

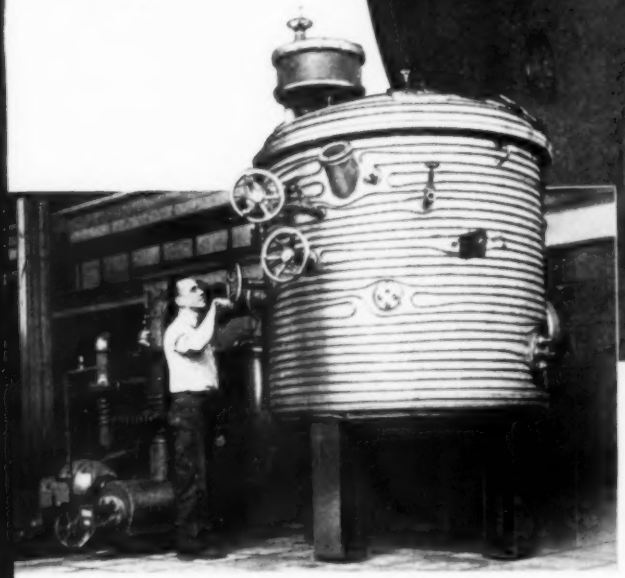
(Continued on p. 214)

*Digest of "Grain Growth in High Speed Steel", by Eric Kula and Morris Cohen, © 1953 Preprint No. 23.

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Grain Coarsening in High Speed Steel

(Continued from p. 212)

of 1900 to 2000° F., rehardening produced an inconsistent effect whereby the coarsening temperature was greater than the prequench temperature. Several graphs show the relationship of these temperatures, and an explanation is given for the anomalous behavior of specimens prequenched from the borderline range of 1900 to 2000° F.

Through a process of postulation and experiment, a new concept is developed for the mechanism of grain coarsening during double hardening. It is established that there are two principal factors which together are responsible for the formation of enlarged grains. One of these is that the pro-eutectoid carbides which precipitate in a finely dispersed form during the second heating cycle tend to anchor grain boundaries and impede grain growth until a certain critical temperature is reached. Then, through solution and coalescence, carbides in certain boundaries are eliminated, permitting some grains to grow very rapidly by absorbing smaller adjacent grains. The other factor is that this behavior of very small carbides does not promote grain growth unless martensite or bainite exists at the beginning of the second heating cycle.

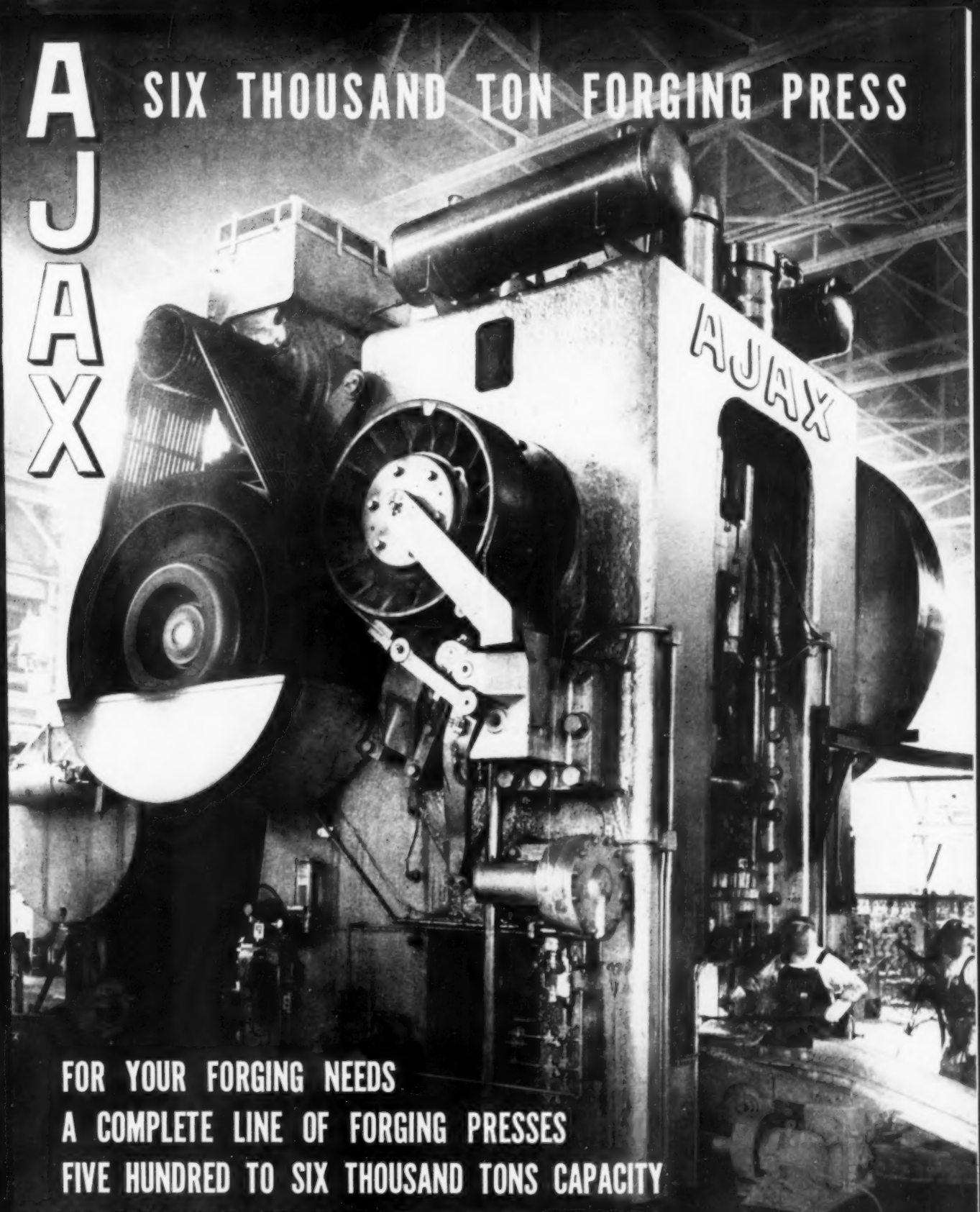
Experiments show that when a fine dispersion of carbides exists in a ferrite matrix, grain coarsening does not occur. It appears that the acicular subgrain structure of martensite or bainite, providing as it does numerous sub-boundaries, which may be anchored and retarded against growth by the finely dispersed pro-eutectoid carbides until a critical temperature is reached, is vitally important to the eventual and sudden grain coarsening. Without this plate-like grain structure, the phenomenon does not occur. Optical and electron micrographs illustrate these effects.

It is found that the most effective way of preventing severe coarsening on second hardening is to eliminate the original martensite or bainite completely, replacing it with a ferrite-carbide structure (spheroidite). This is readily accomplished by some form of annealing or long-time tempering treatment. Experiments show

(Continued on p. 216)

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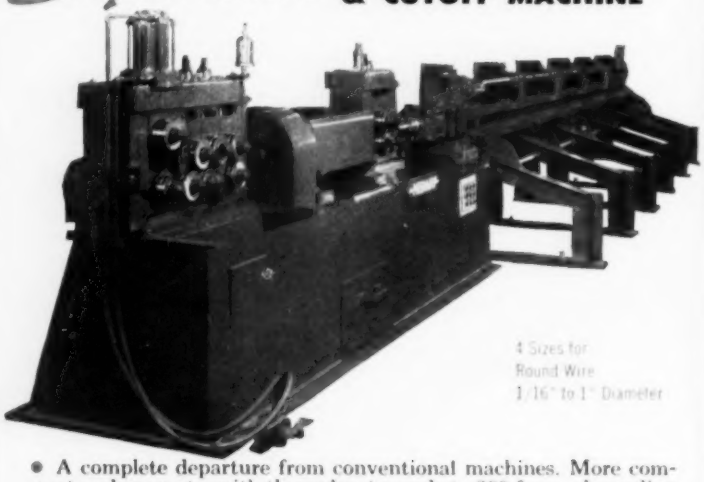
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Grain Coarsening in High Speed Steel

(Continued from p. 214)

that once grain coarsening has occurred and a fishscale structure has developed, it is possible to refine the structure by means of annealing, although a single anneal will not produce a grain size quite as small as is normally developed with a single hardening treatment.

Some comparison is made between this conception of grain growth in high speed steel and the mechanism of grain growth and recrystallization in other metals, such as tungsten, silver, aluminum-manganese alloys, and cold worked Al-Zn alloys.

W. E. Bancroft

Isothermal Transformations in Ferritic Stainless Steels*

THIS PAPER describes the complex isothermal transformations which occur in both the austenite and delta ferrite of commercial ferritic stainless steels when heated sufficiently for complete solution of the carbides and nitrides. Three grades of alloys were studied: Type 430 (17% Cr), Type 442 (21% Cr) and Type 446 (25% Cr). The steels were from commercial heats and were available as hot rolled, annealed and pickled plate. The austenitizing temperature was 2000° F. for the 17% Cr steel, and 2300° F. for the other two grades. Lead baths were used for the transformation studies up to 1900° F., and electric muffle furnaces at 2000 and 2100° F. The structural transformation products were identified mainly by metallographic procedures employing different etchants.

The A_1 temperature was found to increase with increasing chromium content, being 1610, 1700 and 1920° F., respectively, for the 17, 21 and 25% Cr alloys. The isothermal transformation data for the austenites of the three alloys are presented as individual TTT-curves. They are of the single "C" type and

(Continued on p. 218)

*Digest of "High-Temperature Transformations in Ferritic Stainless Steels Containing 17 to 25% Chromium" by A. E. Nehrenberg and Peter Lillys, 1953 Preprint No. 31.



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Isothermal Transformations in Ferritic Stainless Steel

(Continued from p. 216)

indicate that the steels do not possess a bainite reaction. Martensite formed only in the 17% Cr steel.

The transformation of austenite at all temperatures below A_1 was preceded by carbide precipitation. Next, there was a separation of ferrite containing little or no precipitated carbides while the precipitation reaction continued at the grain boundaries. Just below A_1 the austenite transformed completely by a combination of the precipitation and ferrite separation reactions.

From 50° F. below the A_1 temperature to 200° F. above, part of the ferrite present transformed isothermally to an aggregate of lamellar carbides in austenite. This transformation exhibited the characteristics of the pearlite reaction in that it nucleated by carbide precipitation and proceeded by the edgewise growth of carbides in phase with a moving interface which is the result of an allotropic transformation. The matrix transformation is the reverse of the pearlite reaction, however.

Evidence is presented which indicates that the decomposition of austenite slightly below A_1 is the result of growth of residual delta-ferrite grains. Similarly, at higher temperatures the changes in proportion of delta-ferrite and austenite result from the growth of one phase into the other. C. L. Clark

Flow and Fracture of Notched Bars*

The static tension test of a circumferentially notched cylindrical bar is a better criterion of service performance than the unnotch tension test when service conditions entail stress raisers. Although many investigations have been made of the effects of variables such as notch sharpness, section size, heat treatment and test temperature, the fac-

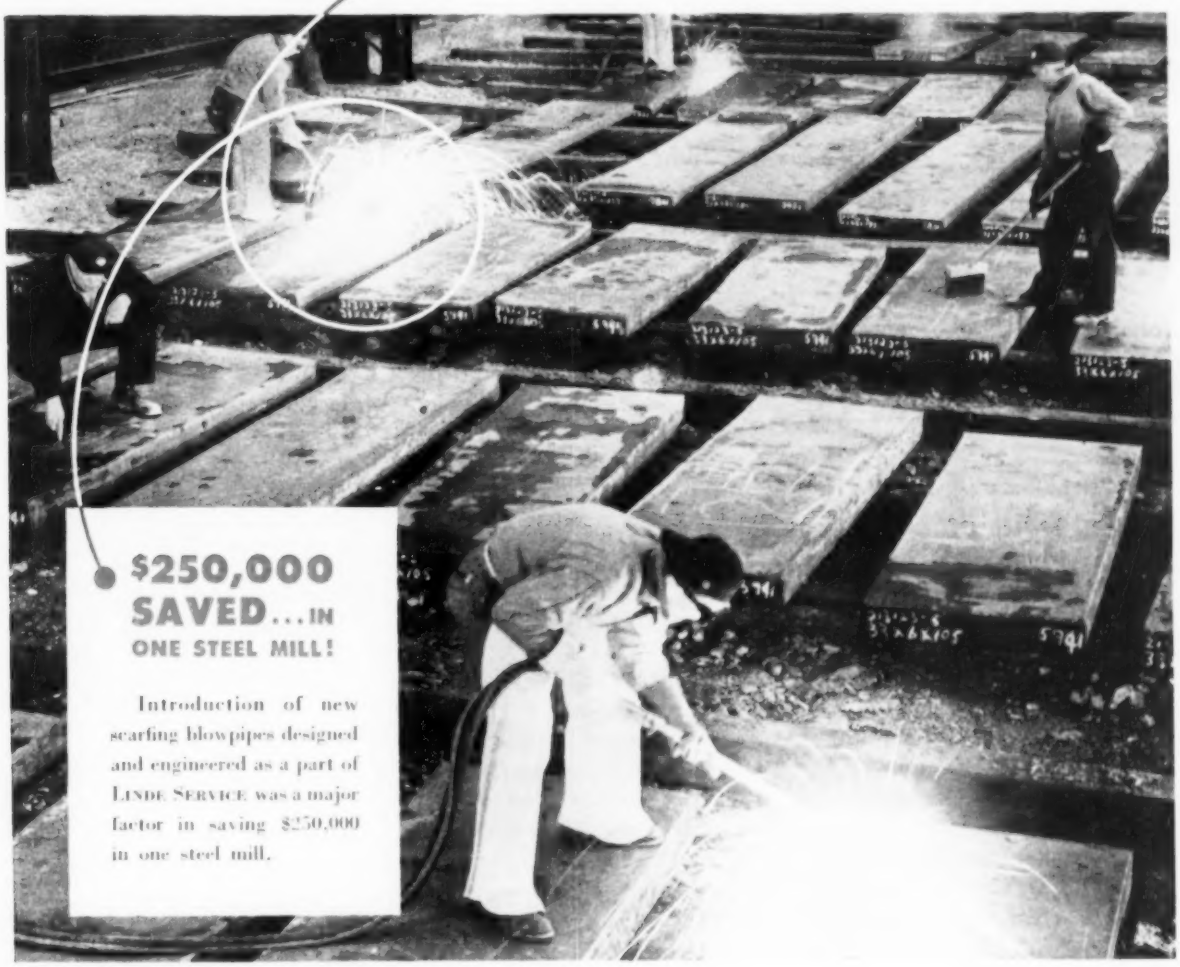
(Continued on p. 220)

*Digest of "Notched-Bar Tensile Properties of Various Materials and Their Relation to the Unnotch Flow Curve and Notch Sharpness", by Harry Schwartzbart and W. F. Brown, Jr., © 1953 Preprint No. 37.

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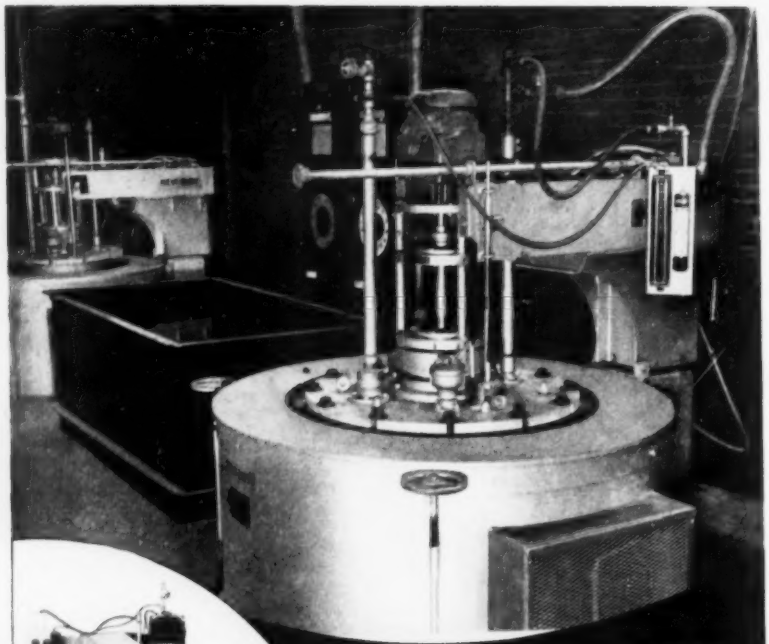
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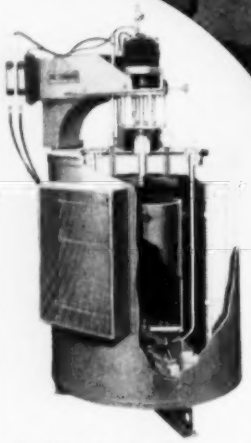
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Flow and Fracture of Notched Bars

(Continued from p. 218)

tors governing flow and fracture of notched bars are still not completely understood.

It was the purpose of the present investigation to examine the influence of the unnotch flow characteristics on the notch properties of a variety of alloys having a wide range of unnotch stress-strain characteristics. Original data on brass, copper, hard drawn copper, titanium, an aluminum alloy, and a "superalloy," as well as previously published data on two aluminum alloys and several ferritic steels, were examined. Heat treatment and temper of certain alloys were varied. The effect of notch sharpness was also investigated.

Cylindrical buttonhead-type tension specimens were used in the investigation. The notch specimens were of the V-type with a flank angle of 60° and with 50% of the cross-sectional area removed by the notch. The notch geometry was described by a parameter called notch sharpness which is equal to $a \div r$, where "a" is half the diameter of the bar at the notch bottom and "r" is the radius of curvature of the notch.

The principal conclusions to be derived from this work may be summarized as follows: As the notch sharpness increases, (*a*) the true stress-strain curve is elevated, and (*b*) the ductility decreases. These effects are most pronounced at low sharpness, decreasing in rate at higher sharpnesses. Both effects in mildly notched specimens are due primarily to the increase in transverse tensions with increasing sharpness. The fracture conditions for a large number of alloys having a sharp notch appear to be controlled primarily by the surface strain gradients which limit the ductility and reduce the fracture stress. These effects are manifested as follows:

1. The yield strength increases continuously with sharpness, rapidly at low and less rapidly at higher sharpness.

2. The notch-strength and fracture-stress usually increase at low sharpness, reach a maximum, then decrease at high sharpness.

An analysis of the data indicates the following relations between the unnotch necking-strain and the tri-

axiality. The higher the unnotch necking strain, or, the higher the relative strain hardening rate:

1. The rate at which triaxiality increases with sharpness is slower.

2. The amount of triaxiality developed is less.

3. The sharpness at which the maximum triaxiality is developed is higher.

The unnotch necking-strain also influences the extent to which the ductility is reduced by a sharp notch. As the necking-strain increases, the ratio of unnotch-to-notch ductility drops rapidly at first, decreases in rate, and becomes constant.

The effect of notch sharpness on the necking-strain and cracking were examined. The necking-strain of mild notches decreases with sharpness for all materials except the hard drawn copper. For this, the necking-strain remains essentially constant at low sharpnesses, then increases to a higher and nearly constant value.

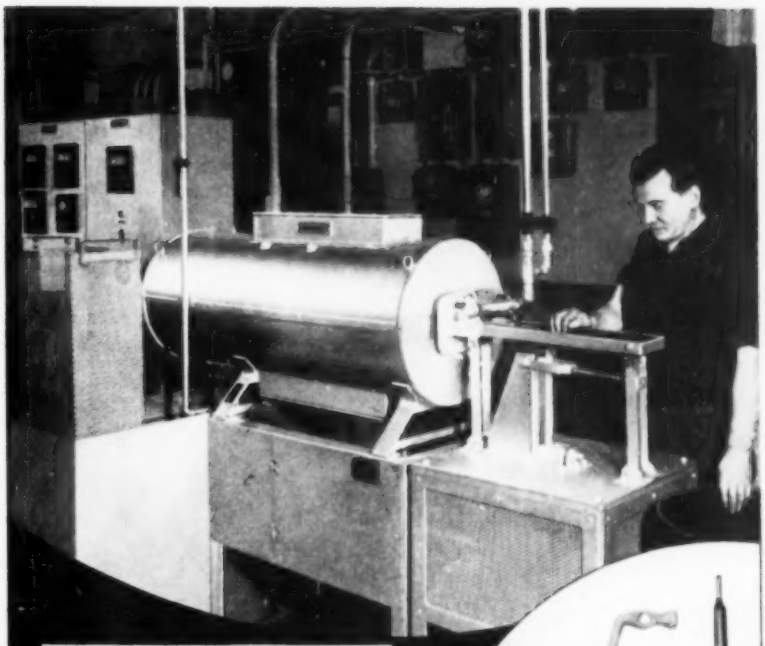
For 24S-O aluminum, brass, titanium, annealed and hard drawn copper, fracture started at the center of the bar for unnotched and mildly notched specimens. The cup-cone type of fracture was obtained. At sharpnesses between 2 and 4, fracture began at the surface of the bar at the notch bottom. The fracture surface was entirely perpendicular to the bar axis, the cup-cone feature having disappeared. This mode of fracturing occurred also at higher sharpnesses. G. V. Smith

High Heating-Rate Strength of Metals*

Changes in microstructure resulting from exceeding the Ac_1 and Ac_3 critical temperatures have been used in the study of heat transfer which occurs in nozzle assemblies of rockets during firing. However, the usefulness of this method of thermal analysis has been handicapped by using the published values for the critical temperatures which were determined at much lower rates of heating, and information was lacking on the magnitude of the elevation of the critical temperatures by

(Continued on p. 222)

*Digest of "Elevation of Critical Temperatures in Steel by High Heating Rates", by W. J. Feuerstein and W. K. Smith. © 1953 Preprint No. 19.



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High Heating-Rate Strength of Metals

(Continued from p. 221)

the high rates of heating such as occur in rocket firing. This report gives the results of critical temperature determinations on A.I.S.I. 1020, 1042, 1080 and 4130 at heating rates from 30 to 2400° F. per sec. Also investigated was the effect of prior microstructure—annealed, and quenched and tempered at 400 and 1250° F., respectively—on the critical temperature of 4130. In addition, a study was made of the effect of a small tensile stress on critical temperatures and elongation during heating through the critical temperature range.

The specimens employed were heated by means of a 600-amp. d.c. arc welder. Up to a heating rate of 1600° F. per sec., critical temperatures were determined by recording elongation and temperature simultaneously on a standard X-Y recorder. Above this rate of heating, which was the limit of full-scale pen travel in 1 sec., critical temperatures were determined by change in resistivity with temperature. Electrical resistivity and temperature were recorded simultaneously with time on a dual-channel magnetic oscillograph. The techniques employed are quite ingenious and should be of interest to other investigators.

A considerable elevation of critical temperatures of the 1020 steel was found with high rates of heating; for example, heating at 1000° F. per sec. resulted in raising the Ac_1 from 1355° F. (encountered in usual heat treating practice) to 1500° F., and Ac_3 from 1570 to 1820° F. The magnitude of elevation was not quite as great with the higher carbon steels. Of interest is the fact that both an Ac_1 and Ac_3 were found in the eutectoid steel (1080). This was attributed to the fact that a finite time is required to complete transformation which is not apparent under equilibrium conditions. Prior structure was also found to affect critical temperatures. A greater elevation of critical temperatures due to heating rate was shown for annealed 4130 than for quenched and tempered, and a greater elevation was shown for the same steel when tempered at 1250° F., than

(Continued on p. 224)

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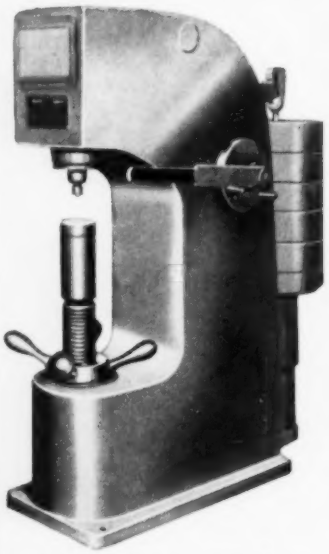


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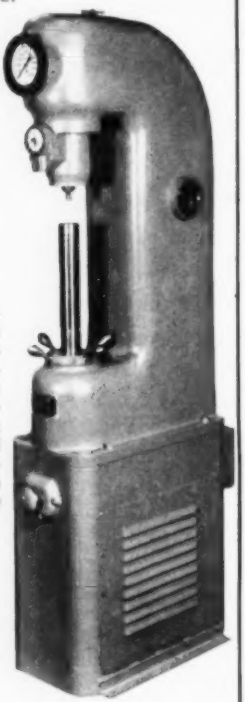
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High Heating-Rate Strength of Metals

(Continued from p. 222)

when tempered at 400° F. The explanation given is that small carbide particles allow rapid nucleation and solution.

A small constant tensile stress, not expected to cause plastic yielding until at least 300° F. above A_{c_1}, applied during heating through the critical range, was found to raise the critical temperatures on the order of 50° F. It also caused plastic deformation as the steel passed through the critical range on either heating or cooling. The authors suggest that this phenomenon may be a source of distortion and dimensional change in heating of large parts which are nonuniform in cross section.

This reviewer believes that the heating rates investigated are within the range commonly employed in high-speed heating such as lead, flame, or induction. The effect of prior structure and heating rate on securing a fully hardened structure generally has been attributed to rate of solution of carbides and the rate of diffusion of carbon in austenite rather than an elevation in critical temperatures. A. H. RAUCH

Intergranular Corrosion of Ferritic Stainless*

ALTHOUGH there is a considerable amount of literature on the intergranular corrosion of austenitic chromium-nickel steels, little data are available with respect to the ferritic stainless steels. Likewise, the theory explaining this type of attack has been accepted for the austenitic steels, but has not for the ferritic grades. The authors point out shortcomings in both the theory of Houdrement and Tofaute (based on formation of carbon-rich austenite) and Hochman (based on chromium impoverishment) and postulate one of their own.

In this work the authors used three grades of the ferritic stainless steels: Type 430 (18% Cr), Type 442 (20% Cr) and Type 446 (27% Cr).

(Continued on p. 228)

★Digest of "Intergranular Corrosion of Ferritic Stainless Steels", by R. A. Lula, A. J. Lena and G. C. Kiefer, © 1953 Preprint No. 32.



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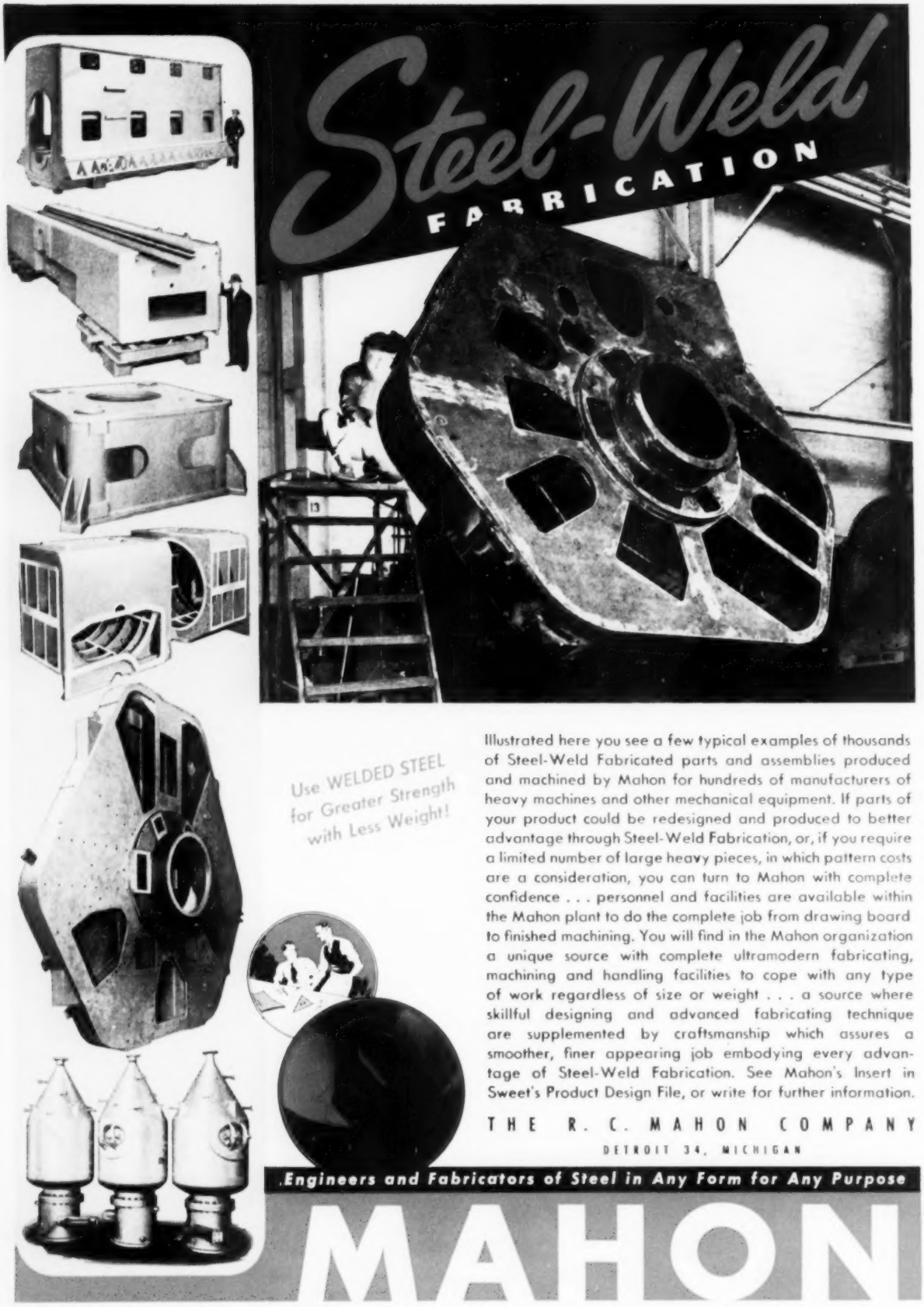
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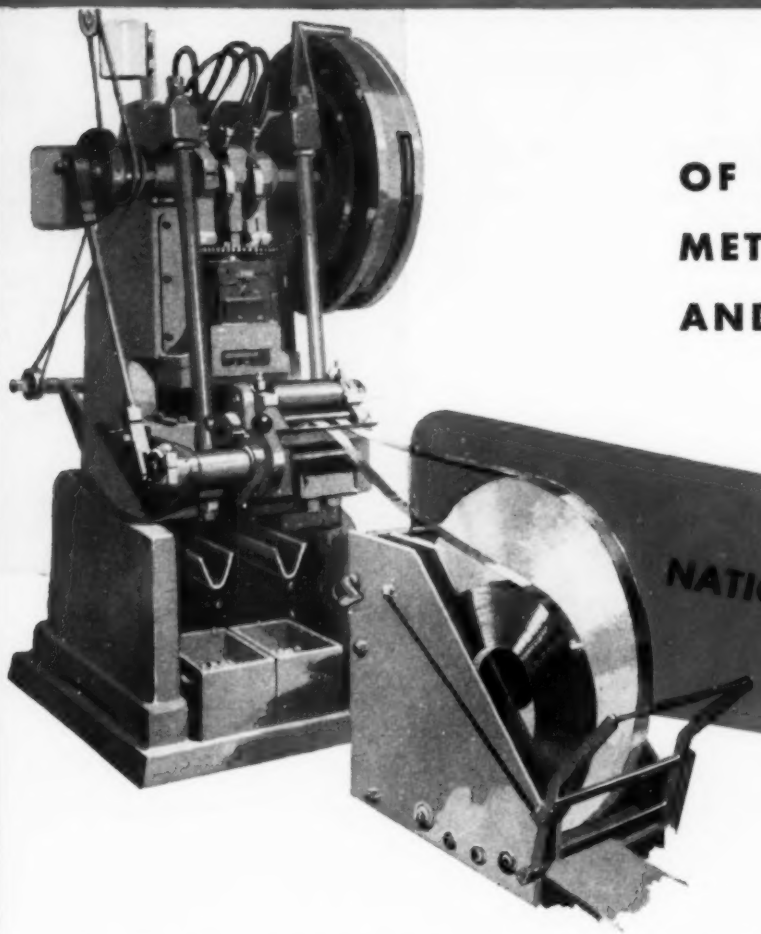
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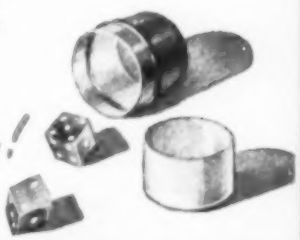
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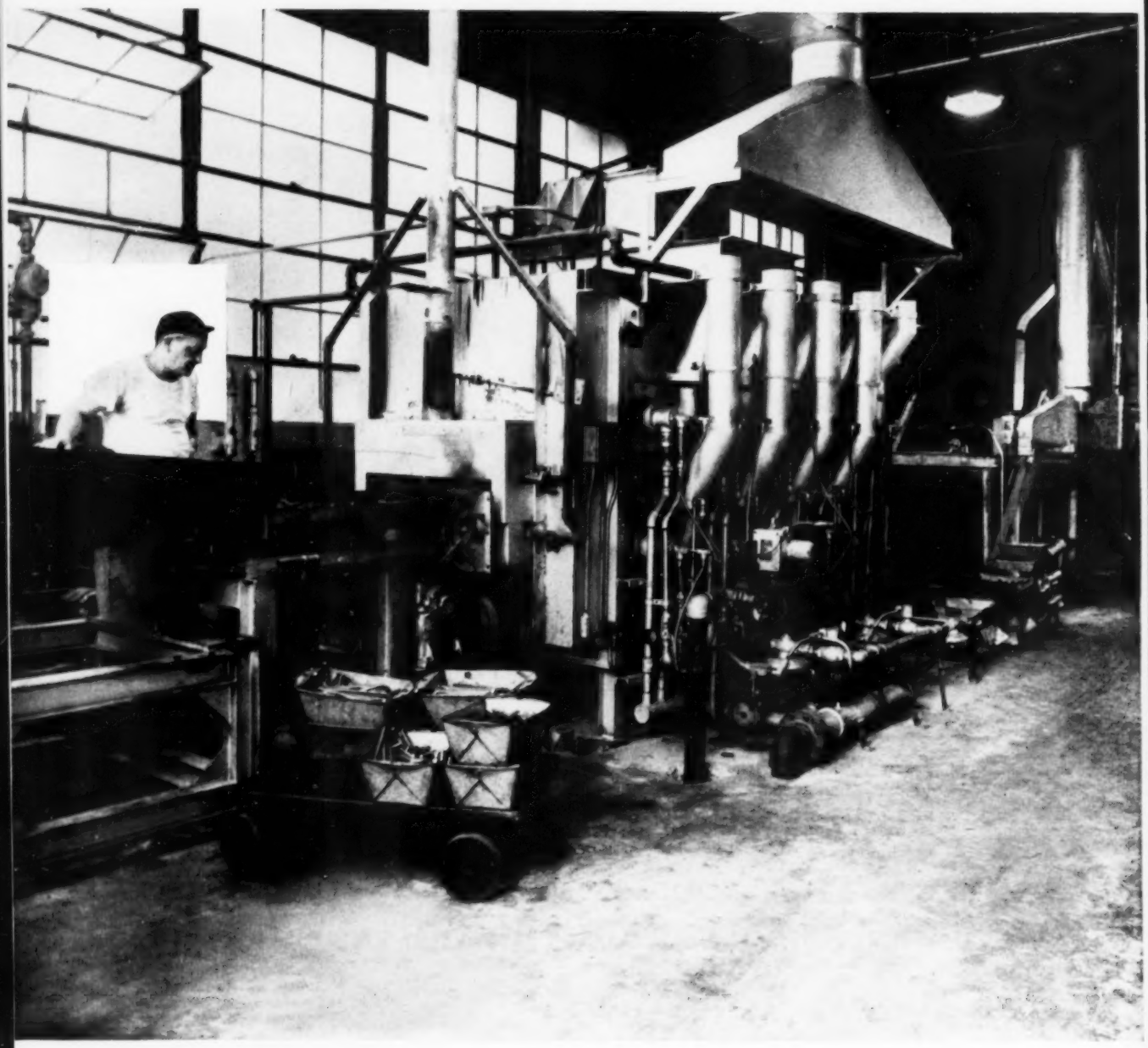
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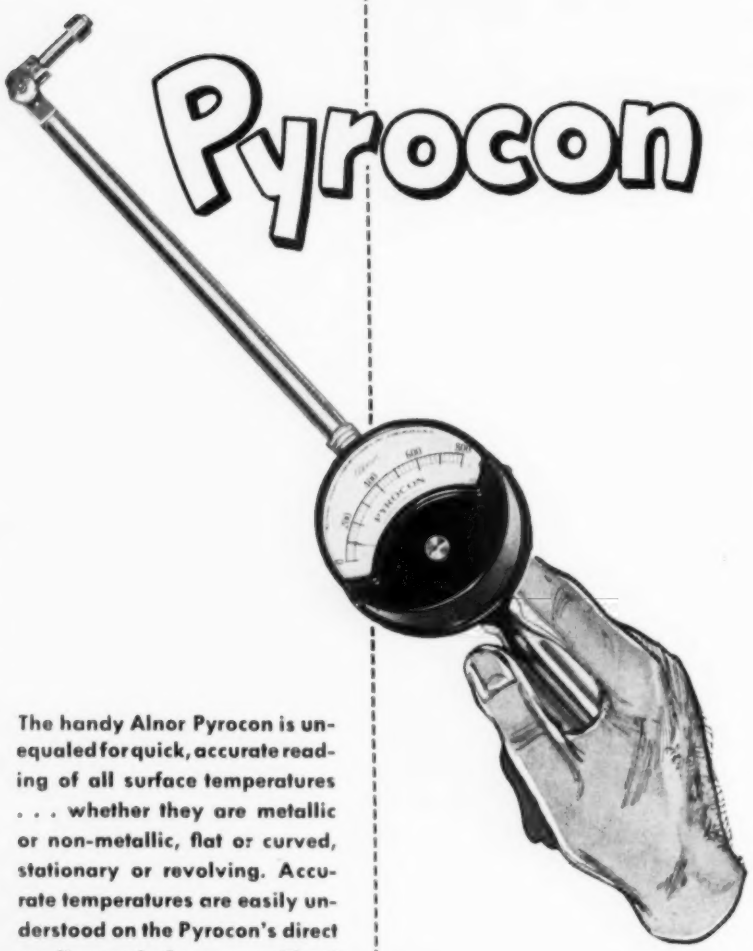
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Intergranular Corrosion of Ferritic Stainless

(Continued from p. 224)

Cr). Modifications in the carbon content and the addition of elements such as titanium, columbium, vanadium and silicon are also considered. The corrosion resistance was determined by both the acidified copper sulphate solution and the 65% nitric acid test, the latter being the most sensitive for detecting intergranular attack in these steels.

Both plain and welded strip specimens were used, and the authors found that each of the steels tested could be sensitized by heating to some temperature above 1700° F., followed by air cooling. Variations in chromium and carbon content, over the range considered, had little influence, but the addition of titanium or columbium, in the proper ratio to the carbon content, did increase the temperature required for sensitization. Also, the sensitivity to intergranular attack could be eliminated in each steel tested by heating within the range of 1200 to 1500° F., and all of the steels were immune when slowly cooled from the sensitizing temperatures.

Thus, the sensitizing conditions for the ferritic and austenitic stainless steels are exactly the reverse. Fast cooling sensitizes the ferritic grades and makes the austenitic type immune. Heating to 1200 to 1500° F. eliminates the susceptibility of the ferritic grades, but makes the austenitic grades susceptible. The addition of columbium or of titanium in the proper ratio to the carbon content prevents austenitic steels from becoming sensitized but not the ferritic grades (on the basis of the nitric acid test).

The results lead the authors to propose a theory regarding the susceptibility of the ferritic stainless steels to the intergranular attack which is as follows: The susceptibility is caused by the grain boundary precipitation from ferrite of either a carbide or nitride phase, and this precipitation strains the matrix adjacent to the precipitate which makes the grain boundary area susceptible to attack in corrosive solutions. Heating at 1200 to 1500° F. relieves the stresses and corrosion resistance is recovered.

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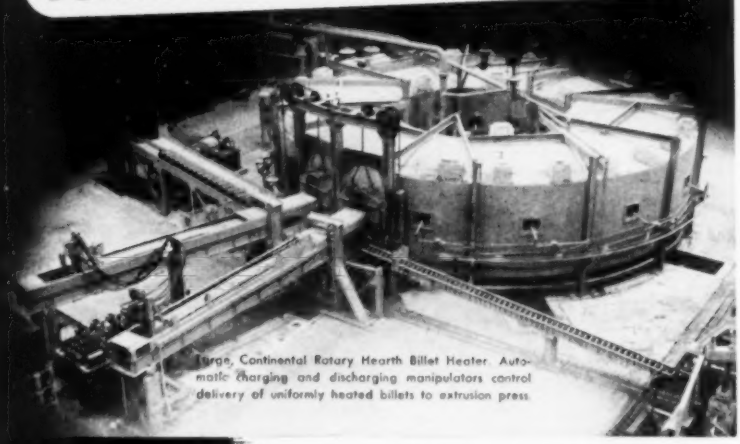
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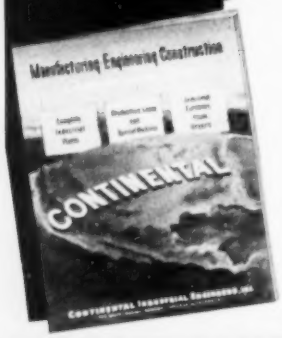
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Effect of Boron and Rare Earths on Transverse-Impact Properties*

THIS PAPER describes an investigation to determine, in part, the separate and combined effects of boron and rare earth additions on the transverse-impact and tensile properties of slack quenched and tempered alloy steels which vary in carbon content, alloy content and hardenability. A method is described for securing samples which vary in degree of slack quenching and which could represent slack quenched structures produced by quenching large forgings. This method consists of end-quenching a specimen 7 in. in diameter and 7 in. long, which was partially cut into eight transverse slabs located at the mid-radius portion. Saw cuts were made prior to heating for end quenching. These cuts were made perpendicular to the radius and parallel to the rolling direction and extended to within ¼ in. of the water quenched end. Cooling rates were determined with thermocouples and these rates compared with cooling rates for the conventional 1-in. end-quench test bar. Except for hardness, all mechanical tests were made on samples that had been tempered in the range of 1000 to 1135° F. in an attempt to secure a uniform hardness and tensile strength along the length of the slabs. Tests included tensile tests on 0.252-in. diameter bars and impact tests on V-notch Charpy impact bars of standard dimensions as well as of reduced width. Tensile and impact properties were plotted as a function of distance from the quenched end.

The specimens near the quenched end did not drop in hardness and tensile strength to the same degree as the slack quenched specimens. In order to secure a valid comparison, the tensile and impact values were adjusted to a constant tensile strength on the basis of work done previously on fully hardened steels.

Impact properties of all steels were adversely affected to varying degrees by slack quenching. Boron appeared

(Continued on p. 232)

*Digest of "Transverse Mechanical Properties of Slack Quenched and Tempered Wrought Steel", by John Vajda and P. E. Busby, © 1953 Preprint No. 9.

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Effect of Boron and Rare Earths on Transverse-Impact Properties

(Continued from p. 230)

to have a beneficial effect on the impact properties of the particular 0.20% carbon alloy steel investigated, but had an adverse effect on the impact properties of the slack quenched structures of the 0.33% carbon alloy steel. This was attributed to a sharp grain boundary delineation, the nature and identity of which is not explained. The addition of rare earths appeared to reduce the adverse effect of boron on slack quenched impact properties according to the data shown for the 40% carbon alloy steel employed. (REVIEWER'S COMMENT: Unfortunately, no one series of steels showed the separate effects of boron and rare earths as well as combined effects.

Rare earth additions had no effect on hardenability nor on impact properties when present alone. Boron increased hardenability, but the improvement found in the conventional end-quench bar was not always apparent on the 7-in. end-quench bar.

A. H. RAUCH

Discontinuous Grain Growth

THE WORK of Kula and Cohen (1953 Preprint No. 33) on the grain coarsening of high speed steel is amplified and extended in this study to eight commercial grades of high speed steel. Preliminary experiments show that there are two distinct patterns for grain coarsening during single austenitizing. One group of steels shows very slight coarsening when austenitized at increasing temperatures within the range commonly employed for commercial hardening. The other group shows a quite appreciable tendency to coarsen with increasing austenitizing temperature throughout the usual hardening range. In both groups the tendency for grain growth is continuous and "fishscale" fractures are not obtained. Discontinuous

(Continued on p. 234)

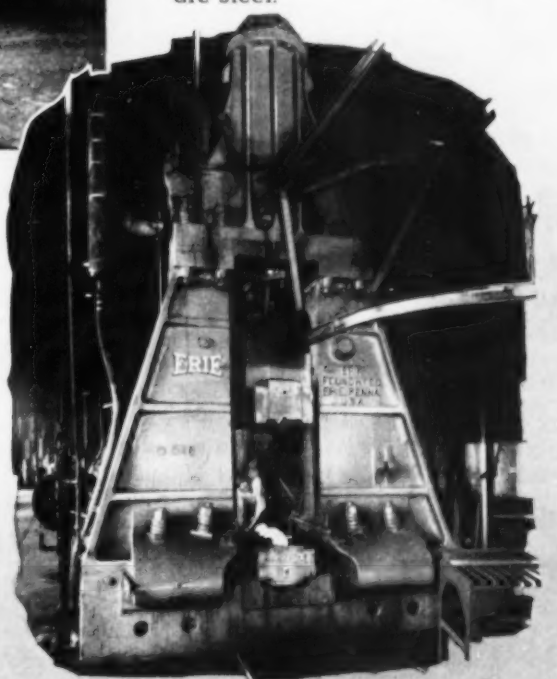
★Digest of "Discontinuous Grain Growth in High Speed Steel," by A. H. Grobe, C. A. Roberts, and D. S. Chambers, 1953 Preprint No. 34.



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Discontinuous Grain Growth

(Continued from p. 232)

grain growth and fishscale fractures were found to occur in all grades that were rehardened after being prequenched from temperatures of approximately 2000° F. or higher. Curves depicting the coarsening temperatures as a function of the prequench temperature and the second quenching temperature for four general-purpose grades of high speed steel are presented.

Observations from the data bolster the theory of Kula and Cohen that grain growth during rehardening is: (*a*) continuous when following a low prequench temperature, (*b*) discontinuous when following high prequench temperatures, (*c*) dependent on the presence or absence of acicular subgrain structures, and (*d*) dependent on the precipitation of very finely dispersed carbides during the second heating cycle.

Graphs for the four grades of high speed steel in which coarsening the temperature is plotted against prequench temperature show that coarsening temperature is high after high initial quenching temperature, decreases to a minimum as prequench temperature decreases and then increases again as the prequench temperature decreases to a minimum in the neighborhood of 2000° F. It is noted that the ultimate coarsened grain size becomes finer as the prequench temperature becomes lower.

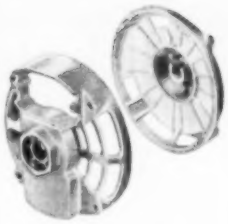
Experiments were conducted to determine the effect of double quenching on hardness after subsequent tempering. Little effect was found except a slight increase in carbide solution and a slightly greater resistance to tempering in specimens double hardened. Microhardness tests showed no significant difference in matrix hardness between very large grains and fine grains in a double quenched specimen.

Some steels other than high speed were investigated, but none were found to coarsen in a discontinuous manner, except a hot work die steel (9% W, 3% Cr) which did show sudden and severe coarsening on second hardening at about 2200° F. after a prequench at 2050° F.

Some discussion is presented on methods of preventing severe grain

(Continued on p. 236)

creative castings



Motor End Frames



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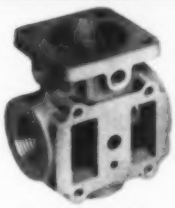
Garbage Disposer Housing



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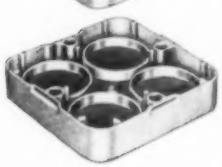


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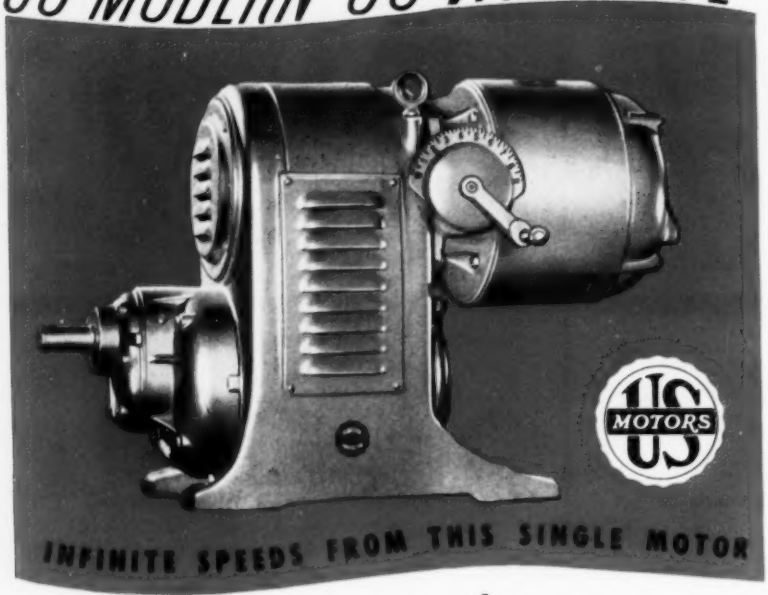
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Discontinuous Grain Growth

(Continued from p. 234)

coarsening on rehardening. Any treatment which eliminates the previous acicular grain structure of martensite or causes gross spheroidization in between the hardening cycles is effective. Tempering alone or slow and controlled reheating cycles were not always effective, unless extremely high temperatures or long times were used. It was found that some intermediate treatments had the effect of raising the coarsening temperature some 75° F.—a fact which may have commercial importance when explored further.

Some data are presented on the effect of annealing treatments on grain size already coarsened by double hardening. A single anneal produces some refinement and eliminates any tendency for discontinuous coarsening on a third quench. Multiple anneals produce slightly more refinement, but no treatment was found which would restore the grain size to its original small size.

Photomicrographs show various stages in the development of coarse grains. It is observed that coarsened grains etch much lighter than fine grains and show an absence of the acicular subgrain structure which is characteristic of uncoarsened grains that will eventually coarsen in a discontinuous manner.

W. E. Bancroft

Polishing Techniques for Titanium

(Starts on p. 129)

the unit with the electrolyte cooled and maintained between 45 and 50° F. In some instances, flatter, cleaner structures were obtained by using a plastic mask which allowed a circular spot 1/10 in. in diameter to be exposed to the electrolyte.

Rem-Cru Titanium, Inc., advocates the use of an alcoholic chloride electrolyte which presents no explosion hazard. It is proportioned as follows: 90% ethyl (or No. 30 denatured) alcohol and 10% *n*-butyl alcohol in which are dissolved, per 100 cc. alcohol, 6 g. anhydrous aluminum chloride followed by 28 g. anhydrous zinc chloride. Electropolishing conditions are 30 to 60 v.

(Continued on p. 240)



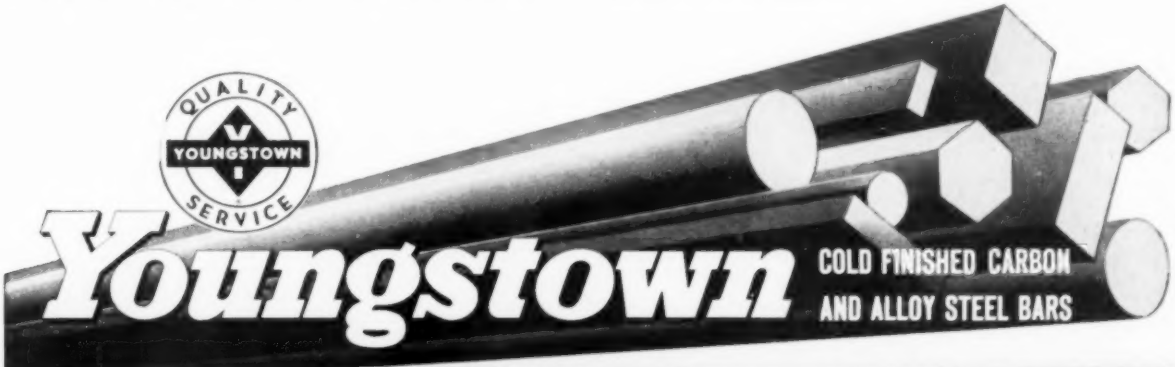
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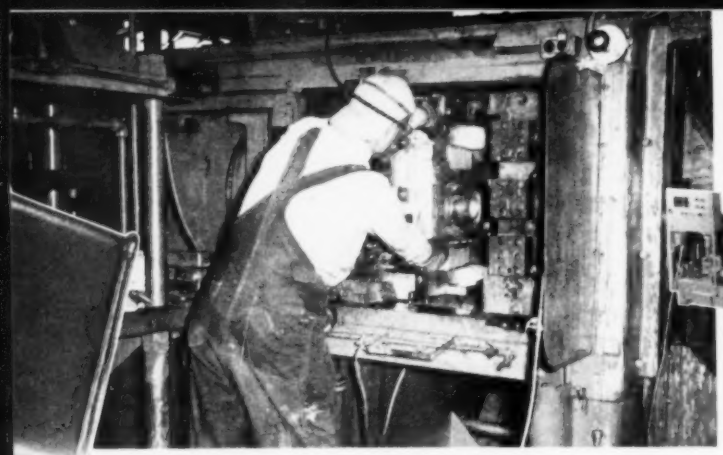
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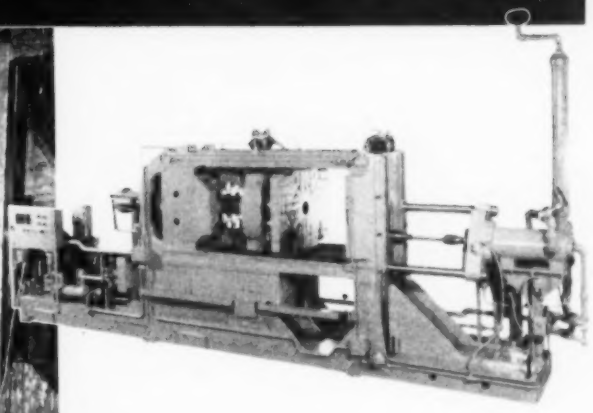
GIANT DIE CASTINGS



LESTER-

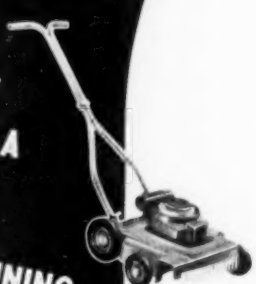
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★ 12-3/4 POUNDS (WITH BISCUIT)
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In the illustration, the slotted element (A) closes the signal circuit contacts at (B), magnetically energizing frame (E) which pulls up armature (C) against pilot contact (D), lighting the dash pilot light and adding to the upward pressure on blade (A). Signal lamp current flowing through blade (A) causes it to heat and bend upward, breaking the lamp circuit and allowing (B) and (C) to fall and break the pilot light circuit. As (A) cools and touches (B) again, the cycle repeats.

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Polishing Technique for Titanium

(Continued from p. 236)

d-c. for 1 to 6 min. at a current density of 1 to 5 amp. per sq.in. of anode. The bath should be agitated and maintained between 75 to 80° F. This solution, which is stable for about one week, can be used in an improvised polishing tank made of glass or plastic. Because of its highly corrosive nature, however, caution should be exercised when using it in commercial polishing units which usually have parts made of stainless steel or other materials not resistant to chlorides.

Many microstructures prepared electrolytically will need no further etching because of the semi-etching effect of this treatment. If required, final etching may be carried out using the appropriate reagent for the particular material, as outlined in the preceding section on etching.

SUMMARY

From the foregoing discussion, it is evident that there is no single satisfactory method for preparing titanium and its alloys for metallographic examination. It was found that each different procedure mentioned required the development of a technique peculiar to it, and all of these variations gave about the same result when properly executed. Keeping simplicity of equipment and technique in mind, a basic procedure has been outlined which is believed to give results equal to those of any other method.

Electrolytic polishing produces results almost equal to those obtainable by mechanical methods and for most applications these results are entirely satisfactory. There is, however, more relief in an electrolytically prepared surface which may be objectionable for high magnification photomicrography. This same relief may also cause trouble in examining the structures of fine-grained multiphased alloys at any magnification. This single drawback seems to be the only important objection to electrolytic preparation of titanium surfaces. But in general, the facility and quickness of this method give it preference over the mechanical methods when the necessary equipment is available.

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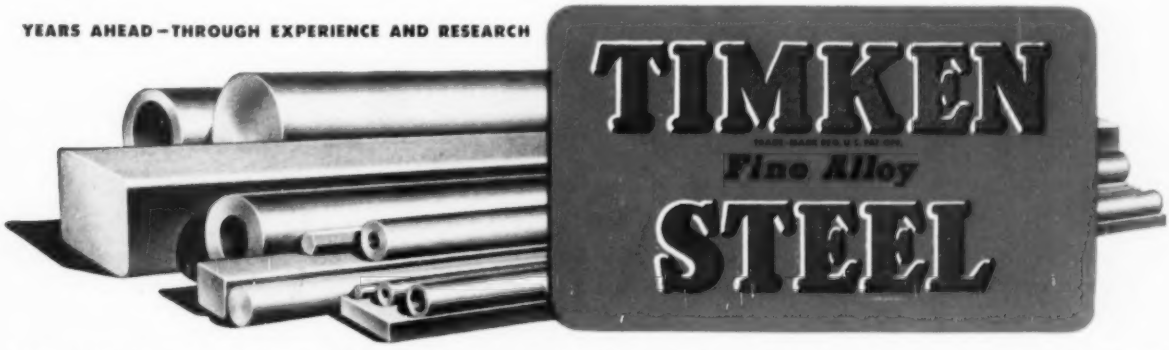
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Photo-Elastic Studies Check Mechanism of Wrapped Wire Joints*

SOLDERLESS wrapped connection of wires to terminal bars in telephone central office switching equipment is now a practical reality (*Metal Progress*, July 1953, p. 161). The method saves countless hours of installation time, facilitates the design of more compact apparatus, and the wires can be readily disconnected if necessary. Uninterrupted and trouble-free service life of at least 40 years is indicated for this new type of joint. Special power tools for making the attachments now are in production, suggesting intriguing potentialities for the method in other industries, notably the electronics field.

Permanence and good electrical characteristics of the wrapped connection hinge on two things—elastic reserve in the metals of the wire and terminal, and solid-state diffusion of these metals as a result of intimate contact where the wire passes over the sharp corners of the terminal bar. Most connections are made with single-strand annealed copper wire wrapped around a rectangular terminal of harder material, such as nickel silver, brass or phosphor bronze. Nominal wire gage is No. 24 (0.020 in. diameter); terminal is a 0.060 x 0.020-in. section. Other terminal shapes, such as U or V sections, work equally well.



Fig. 1—Photo-Elastic Model (Left) Simulating an Actual Wrapped Solderless Connection at the Right. Photo-Elastic bakelite is used to represent the terminal material

What strains develop in the terminals and wrapping wires? How do they change with terminal shape, winding force and other variables? Partial answers may be surmised from winding conditions and terminal shape, yet it is difficult to fix quantitative results by calculation, since the desirable terminal shapes are complicated and many of the strains present are in the plastic region of the metals involved.

Photo-elastic and photoplastic techniques offer means of gaging these inherent forces. For the inside terminals, all the strains, except at corners where wires make firm and deforming contact, are elastic and can be approximated with an ordinary photo-elastic study using a bakelite model of the terminal. Figure 1 shows one such model alongside the actual metal-wrapped connection it stimulates. While the ratios of the wire diameter to terminal dimensions are somewhat different in the model, it still can be productive of valuable

(Continued on p. 244)

*Comprehensive digest of a technical paper, "Necessary Conditions for Obtaining a Permanent Solderless Wrapped Connection," by W. P. Mason and T. F. Osmer, Bell Telephone Laboratories, Inc., Murray Hill, N. J.



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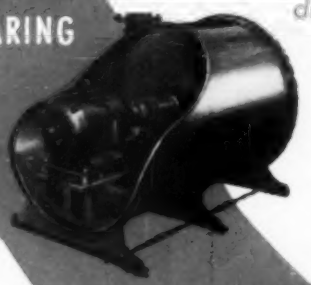
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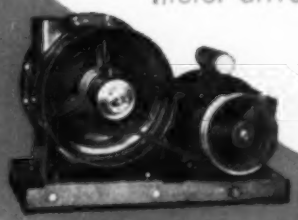
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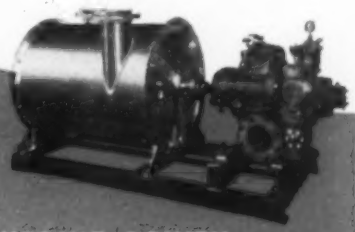
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Photo-Elastic Studies of Wrapped Wire Joints

(Continued from p. 242)

information about strains in the terminals and wires.

The calibrated wrapping "gun" used in commercial practice naturally puts a predetermined tension on the wire. To stimulate this tension, the photo-elastic model is placed in a chuck, one end of the wire is anchored to the chuck and an appropriate weight is applied to the other end of the wire. The specimen then is rotated and a definite number of turns of copper wire wound around it. Extra wire is clipped off, and it is found that the wire adheres tightly to the terminal just as in the real connection.

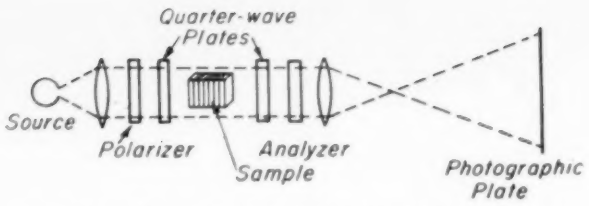


Fig. 2–Elements of the Polariscope Used for Photo-Elastic Studies. Quarter-wave plates eliminate isoclinic lines marking directions of the slow and fast axes of the plastic material

Next the specimen is polished on the two ends up to the end wires and is placed into the polariscope of a photographic analyzer. To obtain the isochromatic lines (those lines occurring when the ordinary and extraordinary rays differ in path length by a half wave length or some multiple of a half wave length), elements of the polariscope, as shown in Fig. 2, contain a quarter-wave plate on either side of the specimen. These have the effect of making the plane wave from the polarizer circularly polarized and eliminate the isoclinic lines which mark the directions of the slow and fast axes of the material.

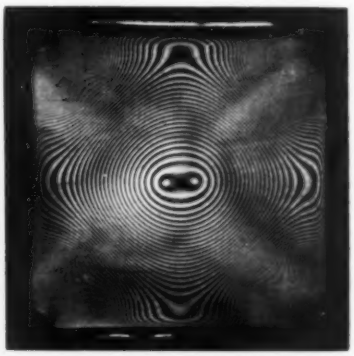
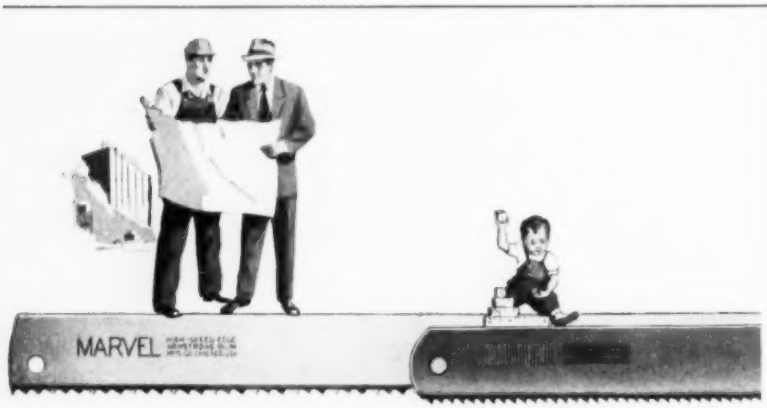


Fig. 3–Isochromatic Lines for Square Model 0.4 In. on a Side, wrapped With 19 turns of 0.050-in. Copper Wire With Constant Load of 28 lb., Equivalent to Stress of 14,300 psi.

Figure 3 shows the isochromatic lines for a 0.4-in. specimen wound with 19 turns of 0.050-in. copper wire under a constant weight of 28 lb., equivalent to a stress of 14,300 psi. Sharpness and number of lines that can be seen suggest a condition of plane stress which can be analyzed in detail. From such analysis it can be shown that the average tension

(Continued on p. 246)



. . . *but*
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Photo-Elastic Studies of Wrapped Wire Joints

(Starts on p. 242)

remaining in the wire, required to balance the compressive stress, is 71% of the winding stress applied to the wire. The remainder is lost in contraction occurring when the wire causes plastic flow at the corners of the specimen.

Plastic flow causes the terminal—whether bakelite or metal—to adjust itself to the wire pressure, providing an airtight joint essential for a good wrapped connection. That the stress in the terminal is enough to do this can be deduced directly from Fig. 3 on p. 244.

Counting lines as far as they can be distinguished by a microscope, there are 72 from the central "eyes" of the picture (isotropic points) up to 0.0525 in. from the geometric corner lines. Using the stress constant of photo-elastic bakelite (88 psi. per fringe per in. length along the optic path), this corresponds to a stress per unit area of 6700 psi.

Since total force on the wire is supported by successively smaller cross sections, as the corners are approached the yield stress of bakelite (15,000 psi.) will be reached at a radius of 0.0235 in. Hence, plastic flow should occur for about 0.023 in. into the plastic. Unwrapping the wires from the terminal substantiates depressions of this order.

One of the requirements of a better connection is that an airtight bond be formed between wire and terminal. Thus, the terminal should have a low enough yield stress so that a sizable groove can be cut in it by the hoop stress of the wire. This rules out such terminals as hardened steel for optimum performance. Copper, brass, aluminum, soft iron and nickel silver are pliable enough to meet this requirement. Any material with a plastic flow limit in compression much lower than the photo-elastic bakelite would probably have such a deep groove that it would be very difficult to maintain the desired hoop stress.

From photo-elastic investigations considerable data have been obtained on desirable shapes for the terminal and limiting winding stresses. One of the most used terminals is the rectangular section. Inspection and calculation show the residual hoop stress per wire to be 60% of the winding stress. The change in shape of the terminal therefore has not made any appreciable difference in the residual hoop stress.

Measurements on the value of winding stress necessary to preserve a hoop stress on the wire—made by winding wires with different weights on photo-elastic samples and measuring the hoop stress—have indicated that to obtain a hoop stress greater than zero the ratio of winding stress to yield stress must be greater than 0.1. To obtain a hoop stress two tenths of the yield stress, a winding stress of 35% of the yield stress is necessary. This is the value which is recommended to give the most stable terminal.

Photo-elastic and other stress measurements for terminals with a high stiffness in torsion are nearly plane stresses; they are all tensions, compressions or shears in a plane perpendicular to the axis of the joint. If, however, the torsional stiffness becomes low, another type of deformation develops—a twist of the whole terminal due to the torque arising from the helical form of the winding.

(Continued on p. 248)

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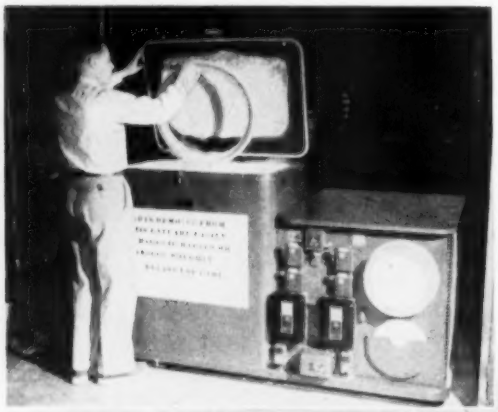
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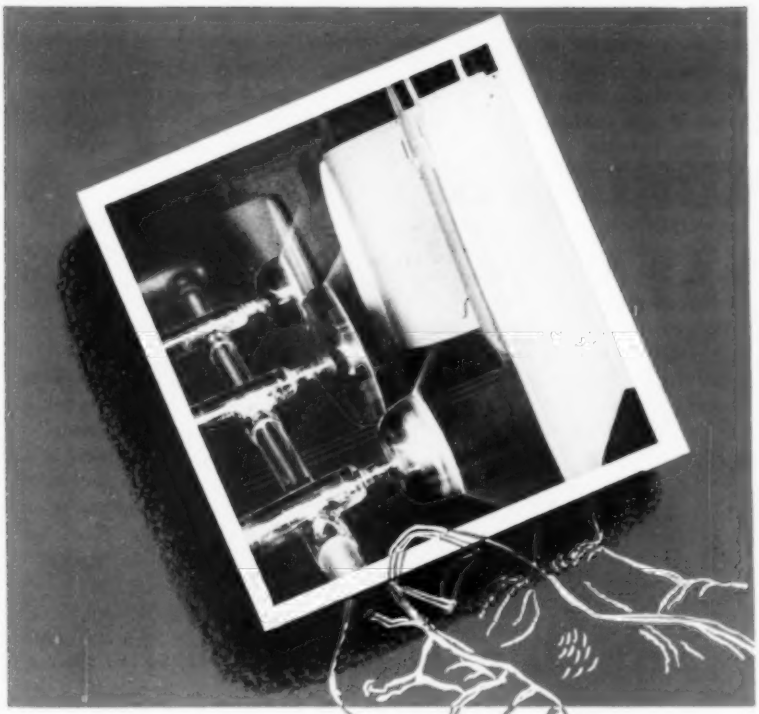
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Photo-Elastic Studies of Wrapped Wire Joints

(Starts on p. 242)

Figure 4 is an example of strain in the terminal when the size of the wrapping wire is comparable to the size of the terminal. A twist in the terminal is obvious, making the stresses three-dimensional rather than plane, and not easily analyzed.

PHOTOPLASTIC ANALYSIS

Strains in the inner block or terminal are elastic except at the corners, and photo-elastic bakelite is therefore a satisfactory material for strain studies. However, the outer wire is necessarily stressed beyond its elastic limit and ordinary photo-elastic techniques cannot be applied. To see if wire strains could be studied with bakelite, tests were made by heating rods to a temperature at which they become elastic, winding them under a stress and cooling under the applied stress. Although the winding process was completed successfully several times, the bakelite rod always broke on cooling, apparently because the material is nearly linear up to the breaking point; in other words, it suffers from brittle fractures and does not simulate a metal in this respect.

Taking the cue from work done by the Bell Laboratories in England on polyethylene, which had demonstrated that it had properties similar to a metal in the plastic range, experiments were made in wrapping a square metal rod with a polyethylene "wire" 1/16 in. in diameter with a wrapping stress about half the yield stress. It was found, however, that the wire "jumped" off the metal rod when the constant stress was released. This was due to the fact that the polyethylene had considerably more recovery than the metal wire and the dissymmetry was not sufficient to lock in the bending stress.

If polyethylene is to be used as a photoplastic material, it is necessary to simulate the unloading curve as well as the loading curve. This can be done by heating the material when it is wound under a load, cooling under a load, and then removing the load at room temperature. Figure 5 on p. 250 shows the loading and unloading curves as a function of temperature. Stress required to produce a given strain decreases very rapidly as the temperature increases, although the recovery remains about the same, irrespective of temperature.

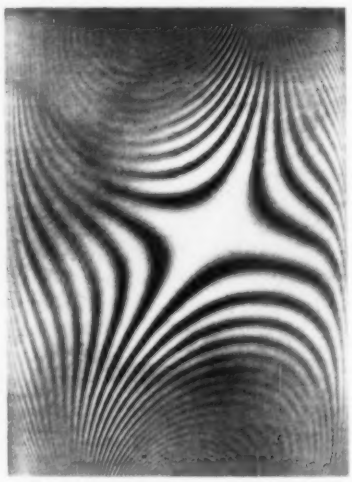


Fig. 4—Photo-Elastic Reproduction of a Terminal When the Outside Wire Diameter Approaches the Terminal Diameter. Resulting twist in the terminal makes stresses three-dimensional rather than plane

To determine whether a wrapped joint would be simulated by this means, a ¼-in. rod of polyethylene was heated to 207° F., wound with

(Continued on p. 250)

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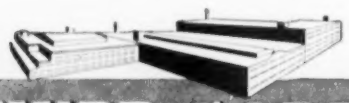
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Photo-Elastic Studies of Wrapped Wire Joints

(Starts on p. 242)

a 1-lb. winding weight and cooled to room temperature with the weight attached. This was enough to prevent the "wire" from unwrapping and when the weight was removed the "wire" gripped the metal closely and formed a bond similar to the wrapped connections. To analyze the strain, a center section of the wire was placed in the polariscope.

As a check, a number of unstrained polyethylene samples were cut by various methods. It was found that if they were cut with a jeweler's saw with a good deal of set to the teeth, no strains were introduced in the sawing process. Using a jig with two parallel guides, a sample 0.040 in. thick was cut through the polyethylene wire. A photo-elastic picture of a wire taken in the center of the wrap is shown in Fig. 6.

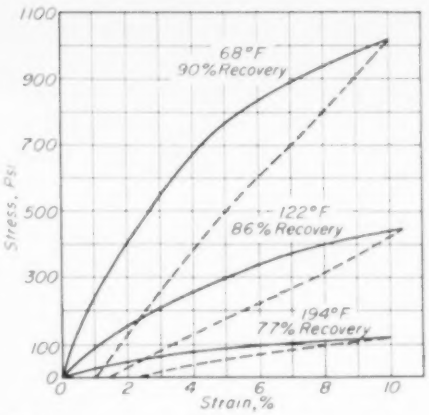


Fig. 5—Stress-Strain Recovery for Quenched Polyethylene as a Function of Temperature Increase

Easiest parts to analyze are the strains in the two "legs" of the sample, since the strains are similar to those for a bent section. The long leg, which was twice as long as the short (horizontal) leg, has its zero order fringe along the inside edge. There are 12 lines to the outer edge, which corresponds to a tensile strain of 16%, with an average tensile strain of about 8%, close to the strain caused by the loading weight.

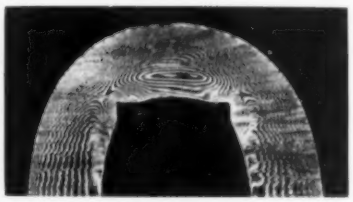


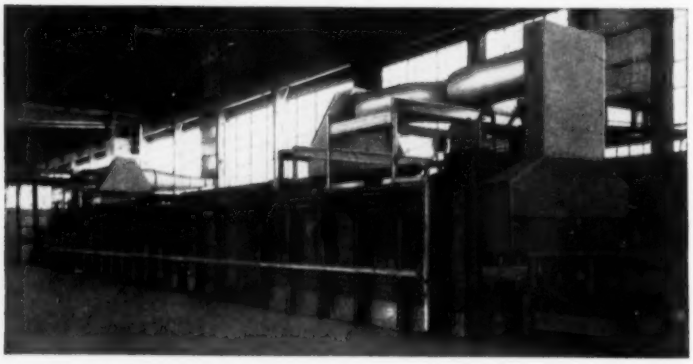
Fig. 6—Photo-Elastic Picture of a Polyethylene "Wire" Wrapped at 207° F. Around a Rectangular Terminal and Cooled Off Under the Applied Load

In the short leg the zero order fringe is the inside oval and the strain is about 11% compressive at the inner edge of the segment and about 38% at the outer edge. These values are consistent with the radius of curvature around which the wire is bent.

To specify properties the wire must have in making a good solderless joint, experiments were made on how much recovery could be tolerated in the wire. Since it is difficult to assemble a series of metal wires having different amounts of recovery, the technique was to heat polyethylene to a definite temperature.

(Continued on p. 252)

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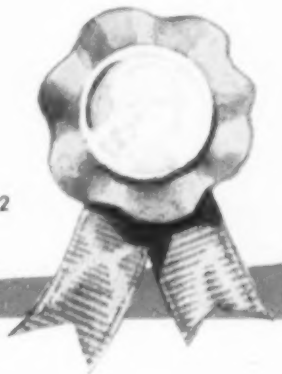
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Photo-Elastic Studies of Wrapped Wire Joints

(Starts on p. 242)

wind under a load equal to half the yield stress at the winding temperature and cool to room temperature under the load. As shown in Fig. 5, known recoveries can be obtained in this way. It was found that the largest recovery that could be tolerated to make a joint at all was 20%, while a reasonable hoop stress was not realized until the recovery was less than 10%.

SUMMARY

To study stresses and strains originating in a solderless wrapped wire-terminal connection, photo-elastic and photoplastic techniques, using bakelite and polyethylene, respectively, have been devised. Polyethylene has a stress-strain curve similar to a metal and can be used to investigate strains in the plastic region.

Using these methods, it can be shown that the connection is held together by the hoop stress in the wrapping wire. To lock this in, a dissymmetry from a circular form is essential. The direction may be an oval shape, square or rectangular. Sharp corners are preferred, since a more definite contact area results.

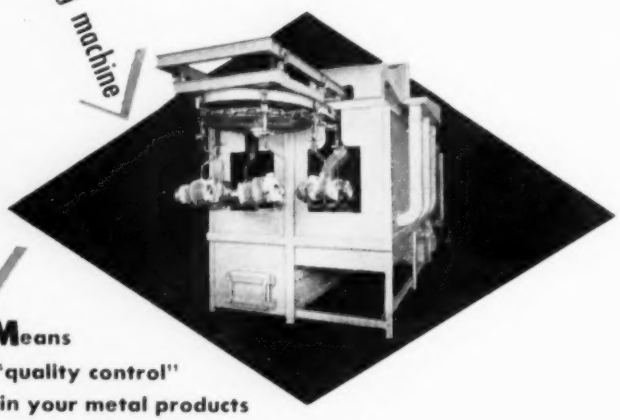
Connection between wire and terminal is sufficiently intimate to permit solid-state diffusion, but the strains are not high enough to cause cold welding of the connection. Life of the joint depends upon the twin processes of stress relaxation and self-diffusion, the latter tending to counteract the effects of the former and thereby yield a pressure connection which should remain unchanged for as long as 40 years.

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Effect of Composition on Temper Brittleness*

THIS PAPER presents results from an investigation undertaken under the sponsorship of the Office of Naval Research to attempt to determine the effect of chemical composition on the susceptibility to temper brittleness. While many consider temper brittleness to be the loss of impact resistance at room temperature as a result of some embrittling treatment, the authors have used the transition temperature as their basis for comparison, and have defined the transition temperature as that at which the impact strength is midway between its values at high and at low temperatures.

The procedure was to austenitize the steels by either oil or water quenching followed by tempering at 600° C. (1112° F.). Half of the specimens were cooled at a rate of 25° F. per hr. from the temper, and the rest were quenched in oil. The bars were then machined into standard V-notch Charpy specimens.

All of the steels considered, with a few exceptions, were melted under helium in laboratory induction furnaces and cast in a chill copper mold into ingots 1¾ in. round and 6 in. long. These ingots were forged into

(Continued on p. 254)

★Digest of "Effect of Chemical Composition on Susceptibility of Steels to Temper Brittleness", by R. Hultgren and J. C. Chang, ⊜ 1953 Preprint No. 26.

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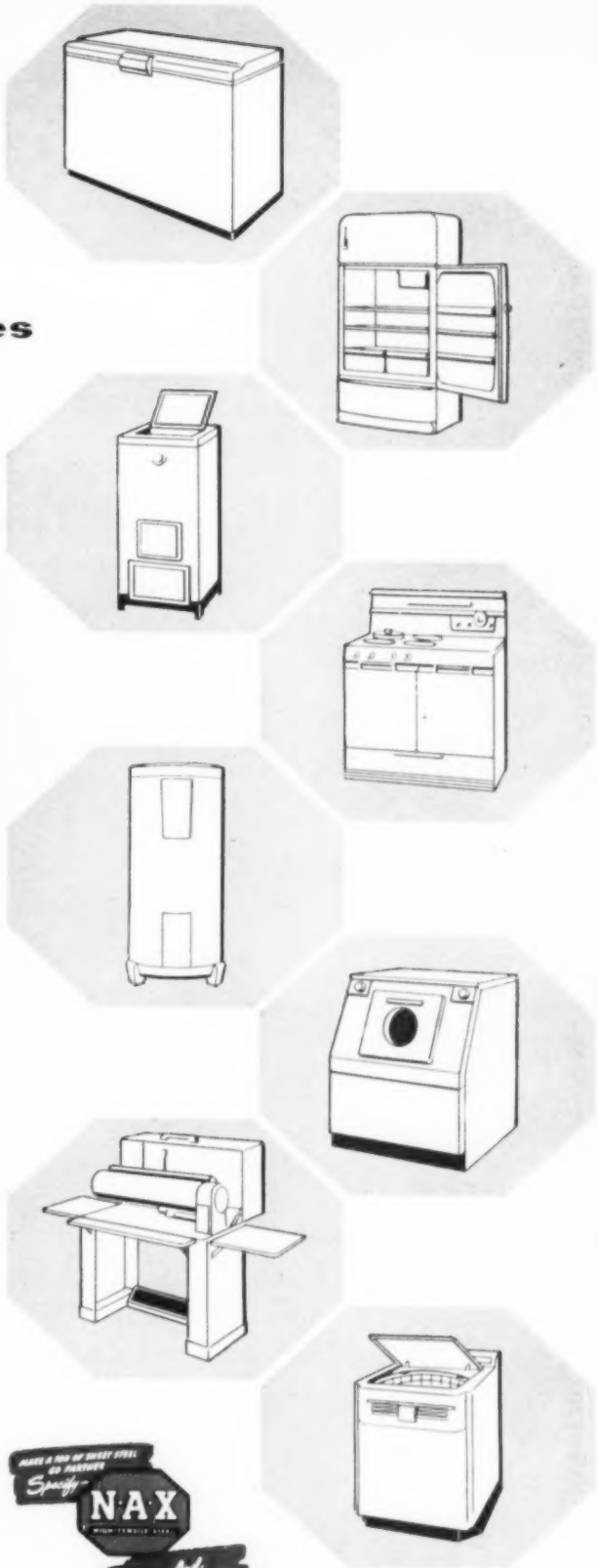
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Effect of Composition on Temper Brittleness

(Continued from p. 252)

½-in. square bars. A wide range of steels was considered and the effect of individual elements on susceptibility to temper brittleness may be summarized as follows:

Carbon—Binary iron-carbon alloys were slightly susceptible when carbon was 0.11% or less. In many of the alloys, greatest susceptibility was at 0.15 to 0.20% C.

Nickel—More than 3% was necessary to make the 0.2% carbon alloy steels susceptible. Chromium reinforced this effect slightly but manganese had a greater influence. Nickel lowered the transition temperature of unembrittled alloys.

Manganese—Alloys with 0.2% C were made strongly susceptible by 2% Mn or more. With the addition of 3.0% Cr, 0.6% Mn was sufficient to cause embrittlement, while 0.5% was sufficient in the Cr-Ni alloys.

Chromium—In the absence of other alloying elements, this element caused little or no susceptibility to embrittlement.

Phosphorus—A few hundredths of a percent imparted susceptibility.

The authors' statement that these conclusions apply to their particular test conditions and cannot be extended too broadly is important, for it is known that the straight chromium steels do become brittle under certain service conditions. The evidence in this paper indicates that if embrittlement is due to a precipitating phase, it must be iron carbide.

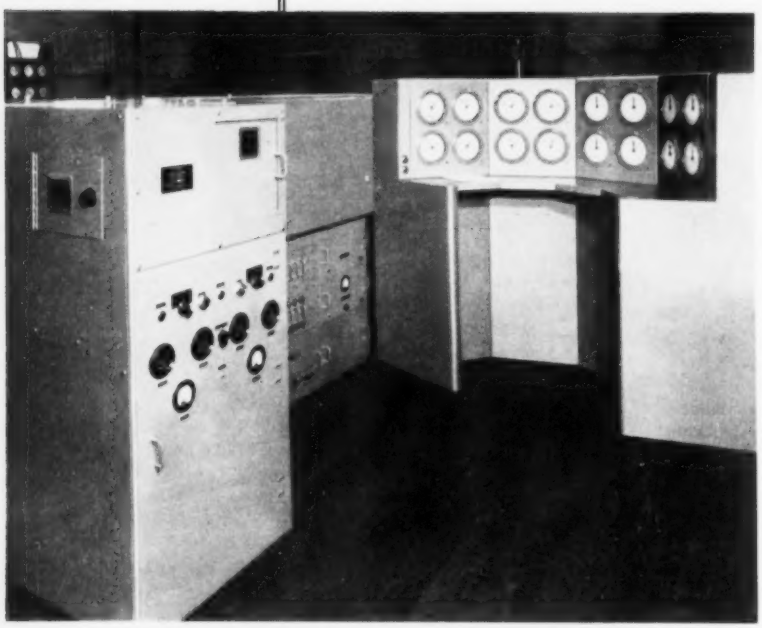
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Microstructural Changes During Tempering

THIS PAPER pertains to the first part of an investigation in which an electron microscope was used to determine the microstructural changes that occur in high-purity iron-carbon alloys after tempering up to 700° F. The alloys contained 0.15, 0.4, 0.8 and 1.4% carbon. Each alloy was austenitized at 2200° F. and at 100° F. above the Ac_1 in order to determine the effect of grain size. All samples were hardened by brine quenching, followed by refrigeration in liquid nitrogen to reduce the amount of retained austenite. Each sample was tempered for 1 hr. at temperatures from 100 to 700° F.

In addition to the electron microscope investigation of microstructural changes, hardness changes on tempering were determined by means of the Rockwell test.

Negative replicas of etched specimens were prepared by using a 1.5% solution of parlodion dissolved in butyl acetate. A technique called "rotary" shadowing using chromium was substituted for the conventional stationary method of shadowing, a method which is supposed to increase the amount of observable detail. Electron micrographs were made at 15,000×.

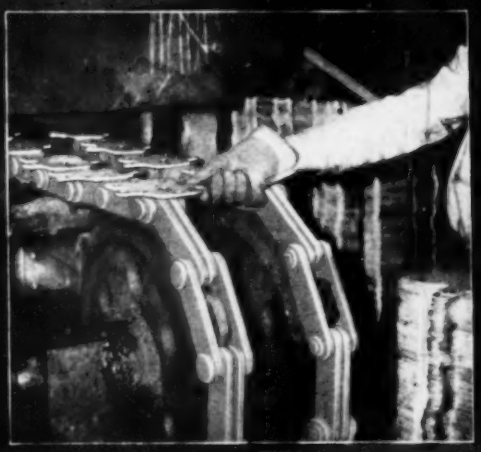
Tempering of martensite was found to occur in three stages. The first stage consists of the precipitation of a constituent, identified by X-ray diffraction as epsilon carbide, along boundaries of subgrains in

(Continued on p. 256)

★Digest of "Microstructural Changes on Tempering Iron-Carbon Alloys", by B. S. Lement, B. L. Averbach, and M. Cohen. © 1953 Preprint No. 25.

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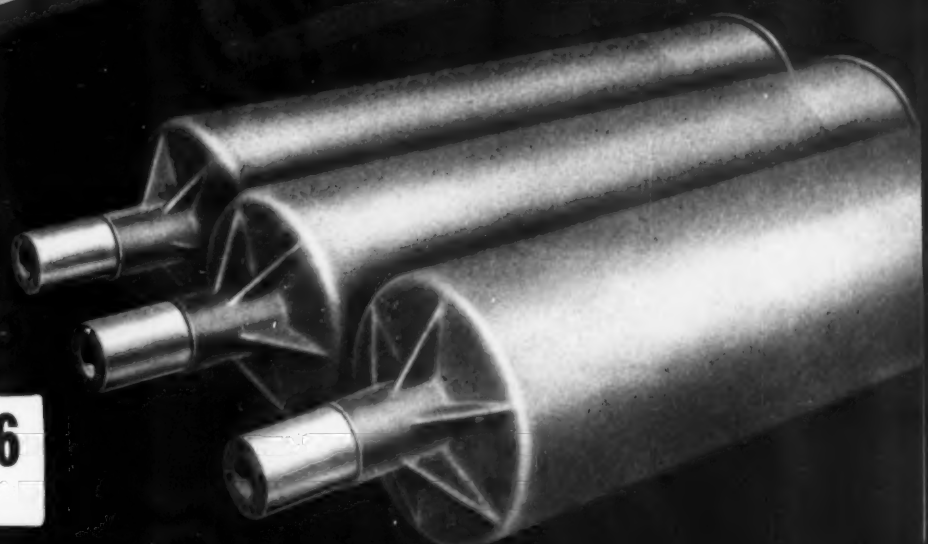


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Microstructural Changes During Tempering

(Continued from p. 254)

martensite containing over 0.25% carbon. These subgrains, about 1000 to 2000 Å in diameter, are said to exist in austenite and are inherited by martensite as a result of the hardening transformation. A sub-boundary carbide network of undetermined identity also forms in martensite of iron-carbon alloys containing less than 0.25% carbon. The second stage of tempering consists of the transformation of austenite to bainite and overlaps the first and third stages.

The third tempering stage consists of the solution of epsilon carbide in the low-carbon martensite matrix, followed by the formation of elongated cementite films at martensite boundaries as well as formation of platelet and globular cementite within the martensite.

The sub-boundary carbide films are first visible at 300 to 450° F., depending upon the carbon content. Elongated carbide films at the martensitic boundaries become visible at 450 to 500° F., along with the formation of globular and platelet cementite within the martensite plates and the concurrent gradual disappearance of sub-boundary carbide. Sub-boundary carbide is virtually absent at 500 to 600° F. An increase in the total amount of carbide precipitated, together with coarsening of the elongated carbide films at martensitic boundaries occurs on tempering at 600 to 700° F. The matrix becomes either ferrite or martensite with a carbon content below 0.25%. The series of changes were essentially the same with 0.15% carbon alloy as in the higher carbon, except that the sub-boundary constituent first formed is not epsilon carbide but another type of carbide constituent.

The microstructural changes that occur on tempering are related to the hardness changes. The slight increase in hardness in the high-carbon alloys and the retarded rate of softening in medium and low-carbon alloys at low tempering temperatures are attributed to the formation of sub-boundary carbide. The softening which occurs and continues with increasing temperature is attributed to two factors, namely: (*a*) the solution of sub-boundary carbide; and (*b*) the depletion of the carbon content of the matrix resulting from the formation of cementite at and within martensitic boundaries.

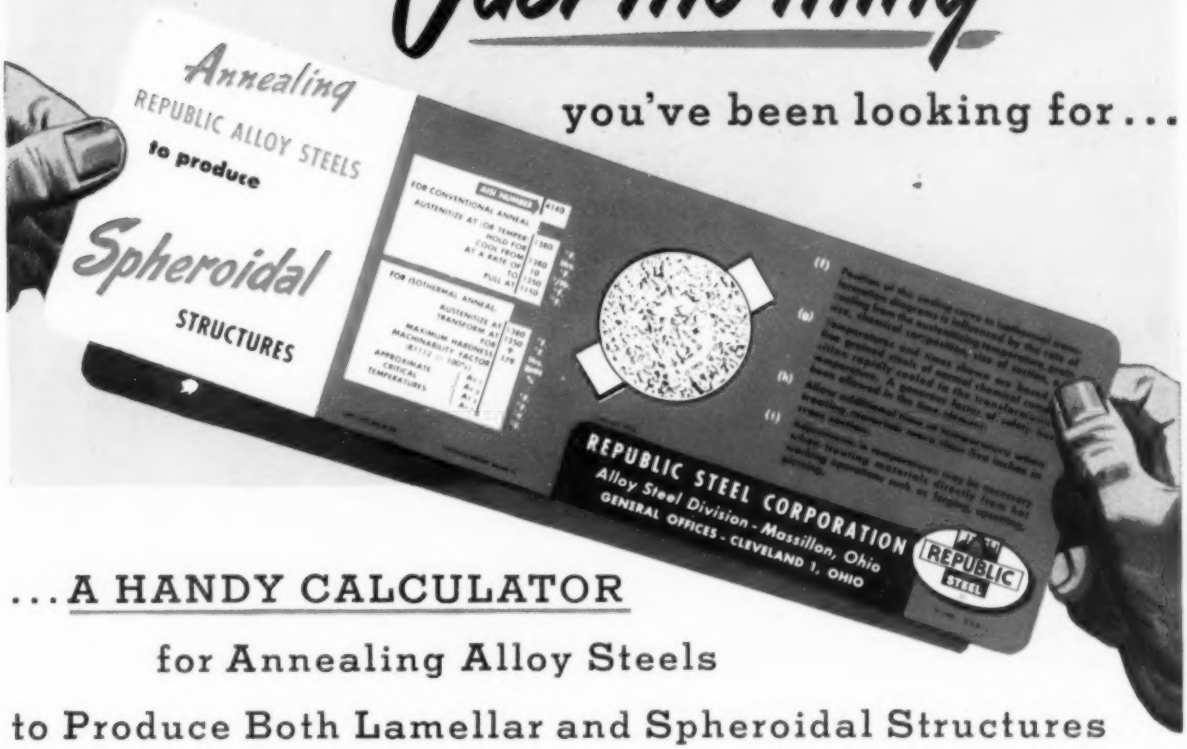
The microstructural changes that occur in tempering are also said to explain the phenomenon known as "500° F. embrittlement" which occurs in hardened steels tempered at 500 to 600° F. and manifests itself in notched impact and notched static tensile behavior. The explanation of this phenomenon in based upon the formation of brittle cementite films at the martensitic boundaries in this temperature range. Build-up of these detrimental cementite films may occur faster at the martensitic boundaries lying at austenitic grain boundaries accounting for intergranular fractures sometimes observed on embrittled samples. Tempering above this range results in increased impact resistance which is attributed to the softening of the matrix caused by carbon depletion.

A. H. Rauch



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Chi Phase in Fe-Cr-Mo Alloys*

ALTHOUGH REPORTS of studies of the Fe-Cr-Mo ternary system have appeared, it has only recently been indicated that "chi" phase, discovered in stainless steels by Andrews in 1949, is stable in this system. The present investigation represents a survey of a portion of the ternary diagram to determine the position of chi phase in the system.

*Digest of "Equilibrium Structures in Fe-Cr-Mo Alloys", by J. G. McMullin, S. F. Reiter and D. G. Ebeling, © 1953 Preprint No. 28.

Isothermal sections at 1500 and 1650° F. were studied.

The alloys used in this investigation, arc-melted in water-cooled copper crucibles under dry argon, ranged in composition (percentage) by weight as follows: Fe, 45 to 85; Cr, 5 to 35; Mo, 1 to 40. Most of the alloys were hot rolled prior to heat treatment, but a few, which could not be so treated, were studied in the as-cast condition.

Hot rolled alloys were solution treated 16 hr. in hydrogen at 2100° F. and water quenched. The as-cast alloys were held 24 hr. at 2200° F. and cooled rapidly in a stream of hydrogen. All of the specimens for the 1500° F. section were held 100 hr. at 1500° F. in hydrogen and water quenched, whereas the 1650° F. specimens were held 72 hr. at temperature before water quenching. That these times were sufficient to establish equilibrium was indicated by study of samples of four alloys after holding for 3, 10 and 30 hr. at 1500° F., which showed the equilibrium structure to be well established after 10 hr.

The phases present were identified and differentiated by X-ray diffraction and microscopic examinations. Diffraction patterns were obtained with a recording X-ray spectrometer, using filtered chromium radiation, directly off the flat surfaces of the heat treated specimens; the specimens had been previously polished and etched electrolytically in ferric chloride to bring the precipitated particles into relief on the surface. The three phases previously reported in this system – namely, ferrite, sigma and epsilon – were readily identified by their diffraction patterns. In addition, the complex cubic phase, chi, reported by Andrews, was identified.

Various etchants, depending upon the alloy composition, were used. Of particular interest, the authors report successful differentiation of sigma and chi phases using a procedure in which the specimen, after a brief attack by a weak acid, is etched electrolytically in concentrated NaOH.

The results are summarized in isothermal sections for 1500 and 1650° F. The two sections are generally similar, the principal difference being that the sigma phase does not extend to the Fe-Cr binary at 1650° F. The most interesting feature of the two sections is the ternary compound, or chi phase, which corresponds approximately to the stoichiometric formula Fe-CrMo. Chi phase appears as the second phase when molybdenum is added to iron-chromium alloys containing from 8 to 27% Cr. In alloys containing about 27% Cr, both sigma and chi may appear. As reported in the literature for commercial alloys, addition of nickel lowers this critical chromium content. It is evident that whether sigma or chi, or both, are stable phases in this and related systems depends upon small differences in composition.

G. V. SMITH

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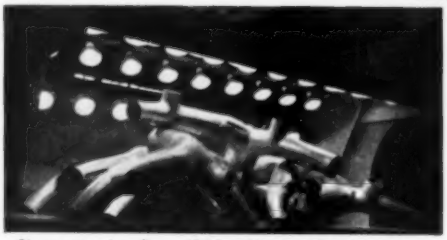
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500° F. Embrittlement in Quenched and Tempered Steels*

FOUR STEELS of commercial alloy types were used in an investigation of the phenomenon of "500° F. embrittlement" in quenched and tempered steels and of the mechanical properties of tempered martensite structures and bainite structures at various strength levels. The steels used were A.I.S.I. 1340, 2340, 4340, and a vanadium-modified 4330. The investigation consisted of determining tensile properties of both martensitic and bainitic structures after various tempering treatments; room-temperature impact energy values for quenched samples in the as-quenched condition, and after tempering in the range of 300 to 1000° F.; room-temperature impact energy values for quenched samples after tempering for durations ranging from 5 min. to 4000 hr. at temperatures from 212 to 700° F.; impact-energy transition curves for quenched samples and bainitic samples tempered at various temperatures; and X-ray diffraction studies to determine the effect of time and temperature on the nature of martensite decomposition products in the steels on tempering.

Room-temperature impact results on samples quenched and tempered in the range of 400 to 700°F. showed a maximum at 400° F. and a minimum in the range of 500 to 600° F. for all steels. In general, embrittlement appeared in relatively short periods of time at the higher temperatures and was displaced to increasingly longer times as the temperature was lowered. The effect of continued tempering, following embrittlement, of the faster tempering steels 1340 and 2340 resulted in improvement of impact energy, indicating that over-aging might be involved. The time required was on the order of 100 hr. or more. The investigation of transition temperatures indicated that 1 hr. in the range of 400 to 500° F. raised the transition temperature over the normal obtained at 800° F., but a shorter time of 5 min. in this range lowered the transition temperature and raised the super-transition impact-energy levels.

Entirely bainitic structures were produced by isothermal transformation at 10 to 20° F. above the Ms temperature. Mixed structures of tempered martensite and bainite were produced by isothermal transformation below Ms. The relationship of tensile strength to hardness was the same in the bainitic structures as in tempered martensite, and the reduction of area and elongation were the same in both structures when compared at the same strength values. These bainitic structures exhibited essentially the same transition temperature in a given steel regardless of the strength level to which they were tempered but the super-transition energy level increased as the strength level of the steel dropped.

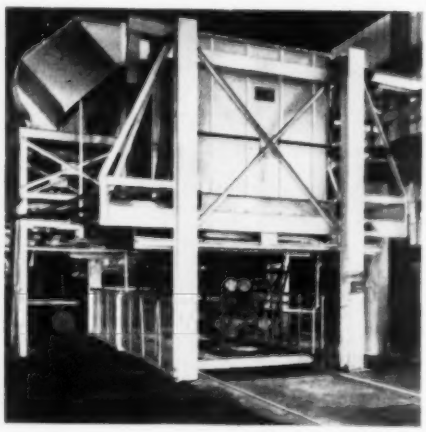
At the same strength level both

(Continued on p. 262)

*Digest of "The Embrittlement of Alloy Steel at High Strength Levels", by L. J. Klingler, W. J. Barnett, R. P. Frohmberg, and A. R. Troiano, 1953 Preprint No. 27.

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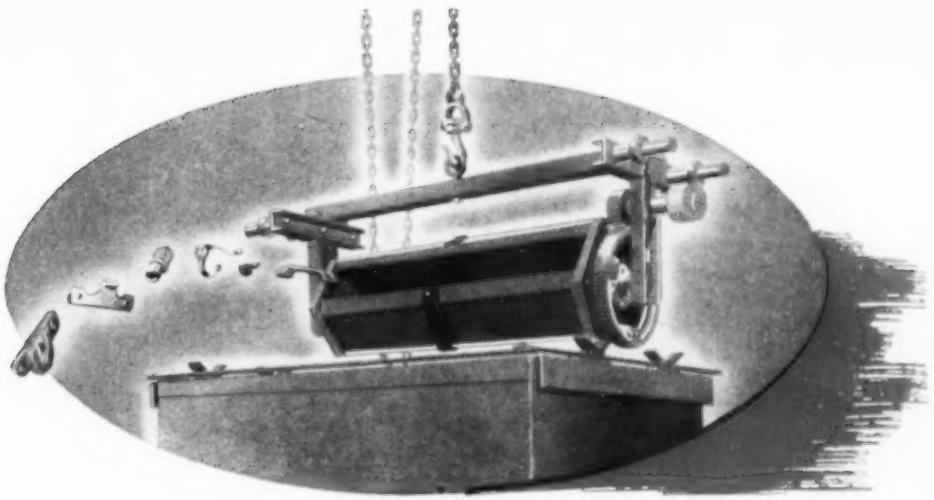
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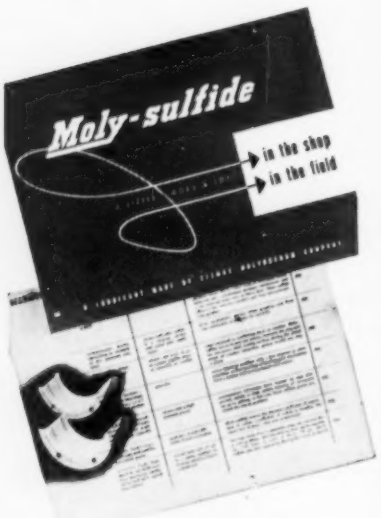
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500° F. Embrittlement of Alloy Steel

(Continued from p. 260)

tempered martensite and tempered bainite had the same transition temperature unless appreciable embrittlement had developed. As the amount of tempered martensite in the mixed structures was increased, the energy level of the entire impact-transition curve tended to drop to that for martensite tempered to the same strength level. Unlike martensite, extended tempering of bainite at 500° F. did not cause deterioration of impact properties, indicating that high-strength bainite is not subject to embrittlement by low temperature aging.

X-ray diffraction examination was made of extracted residues of samples quenched and tempered at various temperatures within the range from 212 to 1000° F., and for times of 30 sec. to 2750 hr. Above 500° F. only the normal diffraction characteristics of cementite were observed. At 500° F. and below, a new structure was found which corresponded to hexagonal close-packed epsilon carbide. The sequence of carbide transition on tempering at 500° F. and below, common to all steels, consisted of the formation of epsilon carbide first, followed by platelet cementite, and finally by conventional cementite.

Composition exhibited a marked influence on the nucleation of cementite which was most rapid in A.I.S.I. 1340 and slowest in 4330. The time-temperature relations for embrittlement and the nature and sequence of carbide structures exhibited a definite relationship; the initiation of embrittlement was always coincident with the initial formation of platelet cementite and the gradual disappearance of epsilon carbide. The X-ray diffraction studies of bainite structures indicated that epsilon carbide was not present. The only carbide constituent was platelet or regular cementite.

Based on impact behavior and changes in structure on tempering, the "500° F. embrittlement" in quenched and tempered steels is said to be due to a precipitation and aging mechanism. It is postulated that, due to the localized precipitation of platelet cementite in the

(Continued on p. 264)

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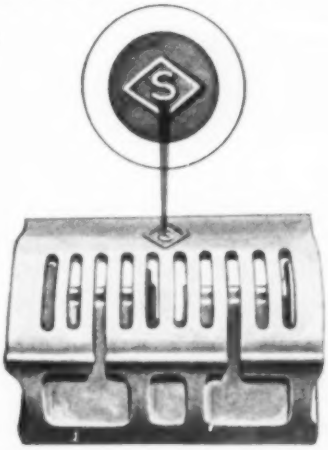
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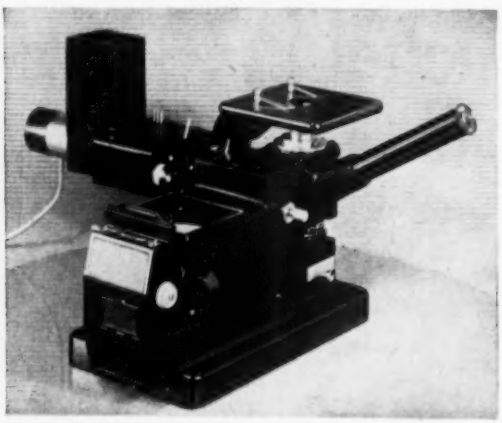
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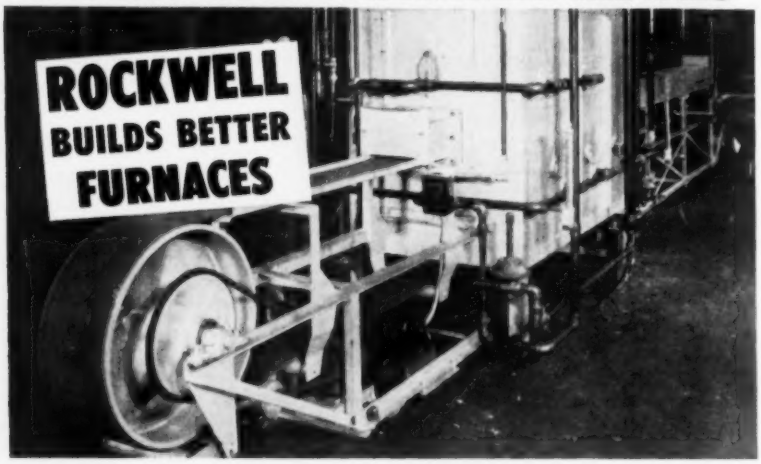
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500° F. Embrittlement of Alloy Steel

(Continued from p. 262)

prior austenite grain boundaries preceding the general precipitation of cementite, a thin ferrite network is produced surrounding higher strength martensite in a less advanced stage of tempering. This condition is thought to be responsible for the brittle behavior. This theory requires that epsilon carbide precipitates first at the grain boundaries but it is in equilibrium with 0.25% carbon martensite which, unlike ferrite, is a relatively high-strength material and does not lead to brittleness.

The authors propose three approaches toward minimizing embrittlement in quenched and tempered steels at high strength levels:

1. Development of special analyses with retarded martensite tempering characteristics.

2. Development of faster tempering martensite steels so that overaging will occur and embrittlement be eliminated in practical tempering time.

3. The development of steels which can be treated to 100% high-strength bainite. A. H. Rauch

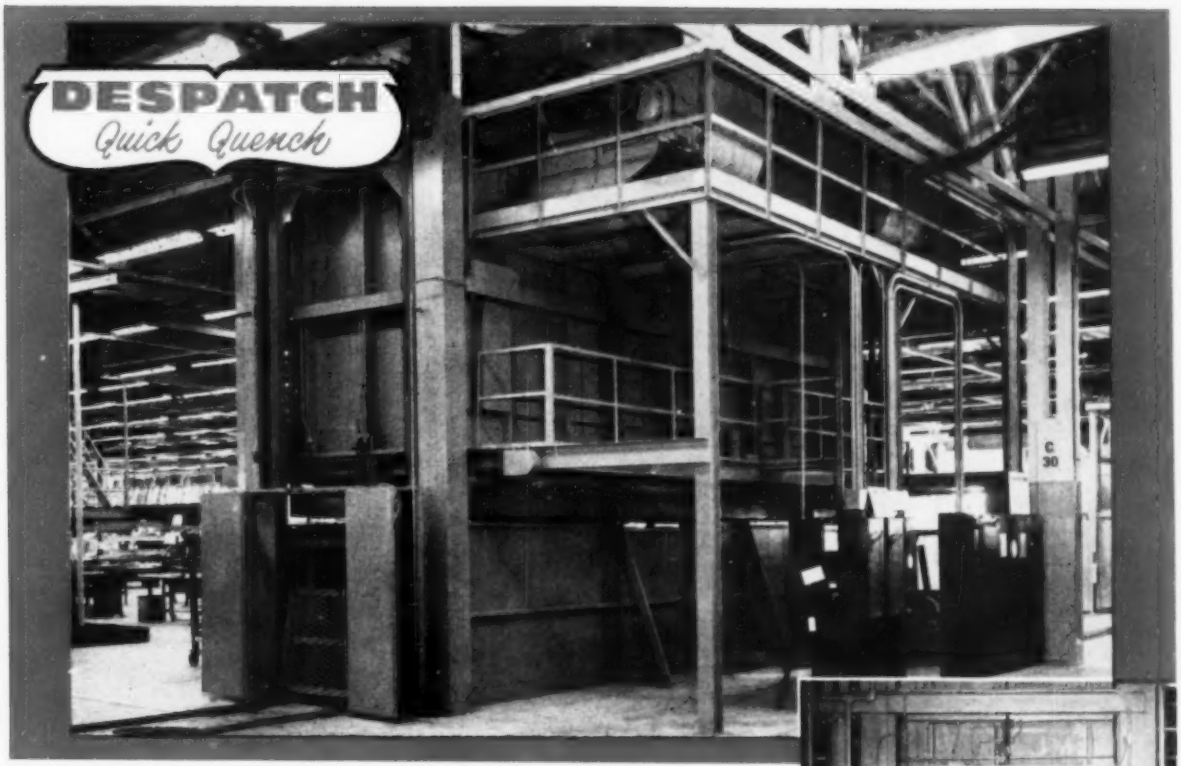
Fracture of High-Purity Ferrite Crystals*

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(Continued on p. 266)

★Digest of "Flow and Fracture of Single Crystals of High-Purity Ferrites", by R. P. Steijn and R. M. Brick, © 1953 Preprint No. 36.



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Fracture of High-Purity Ferrite Crystals

(Continued from p. 264)

was used for the final deoxidation.

To produce the single crystals, strips of these steels were plastically strained a critical amount and annealed at progressively increasing temperatures from 450 to 890° C. (840 to 1635° F.) in a helium atmosphere. The single crystals thus produced occupied the 0.200 x 1-in. gage section of the tensile test bars.

The single crystals were polished electrolytically and their orientation, both before and after deformation, was determined using the Laue back-reflection technique.

Tension and compression tests were conducted at temperatures varying from room down to liquid air. The rate of straining was 0.01 in. per in. per min. After deformation, the position of the glide ellipses was determined microscopically from the surface slip markings.

As a result of this investigation the authors conclude:

1. Slip in iron occurs on planes of the (111) zone. The resistance to shear in these planes varies continuously between the (110), $\Psi=0$, and the (112), $\Psi=30°$.

2. There is strong evidence that tensile and compression deformation are not the same as far as the selection of the glide plane is concerned.

3. Low-temperature deformation, whether by tension or compression, always shifts the selected glide plane toward the (110) side of the zone.

4. The nature of fracture of single crystals is dependent on the temperature and the crystal orientation. All crystals were ductile at room temperature and showed brittle cleavage at −185° C. (−300° F.).

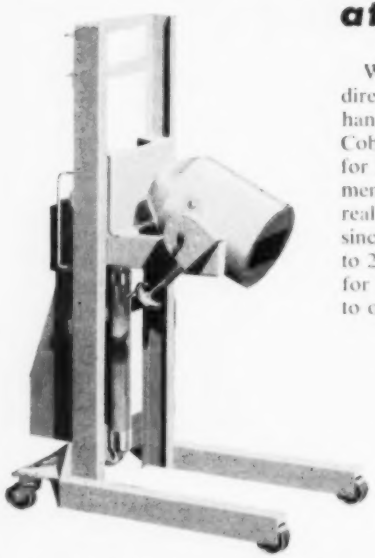
5. Observations on mechanical twinning confirmed the belief that a critically resolved shear stress is not the criterion for twinning.

6. The dodecahedral critical shear stress for slip increases sharply with decrease of temperature below room temperature.

7. Slip on high-indices planes can

(Continued on p. 268)

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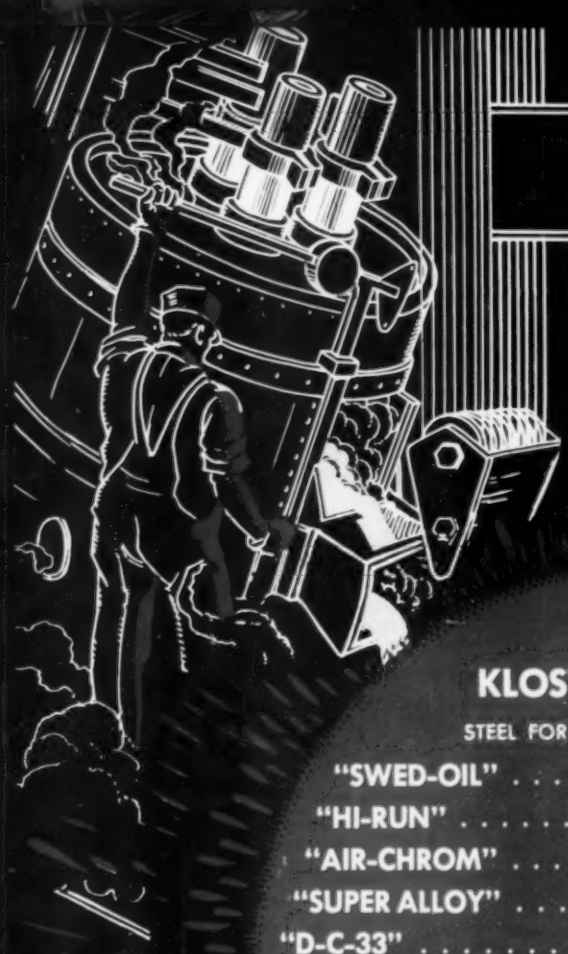
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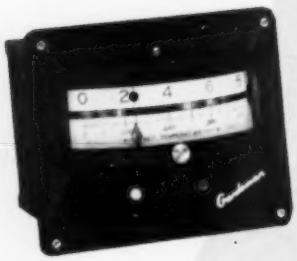
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Fracture of High-Purity Ferrite Crystals

(Continued from p. 266)

be explained by considering the atom movements required by (111) shear in a hard sphere model of a body-centered cubic lattice. Hypothetical curves are deduced showing the relative variation of the resistance to shear along the (111) zone. On the basis of these curves, some observations regarding slip on body-centered cubic metals and alloys can be explained qualitatively.

C. L. Clark

Effect of Pearlite Spacing on the Transition Temperature of Steel*

The effect of pearlite spacing or interlamellar distance on impact transition temperature and tensile properties is described for four steels ranging in carbon content from 0.01% to 0.78%. A variation in interlamellar spacing was attained by quenching into lead at 900, 1000, 1100, 1200 and 1250° F. All steels were melted in a basic-lined induction furnace and were fully killed with aluminum.

Four criteria for determining temperature were: (*a*) average energy; (*b*) temperature at 20 ft.-lb.; (*c*) 50% brittle fracture; and (*d*) first sign of brittle behavior. In the 0.01% carbon steel no difference in transition temperature was found when the lead quench bath temperature was varied from 1250 to 900° F., regardless of the criterion employed. This would indicate that the transition temperature of ferrite is unaffected by quenching temperature.

In the 0.20 and 0.40% carbon steels, transition temperatures were lowered with decreasing pearlite spacing with all methods of evaluation. In the eutectoid steel, however, only the "20 ft-lb." transition temperature criterion indicates any effect of pearlite spacing on transition temperature, the temperature being lowered with finer spacing; the other criteria indicate no effect whatsoever of interlamellar spacing.

(Continued on p. 270)

★Digest of "The Effect of Pearlite Spacing on Transition Temperature of Steel at Four Carbon Levels", by J. A. Rinebolt, © 1953 Preprint 18.

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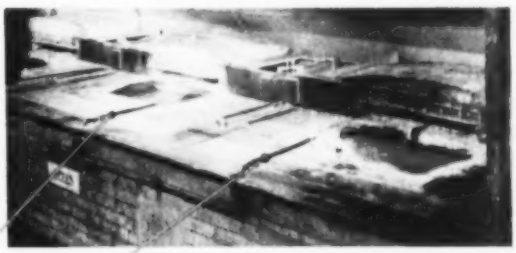
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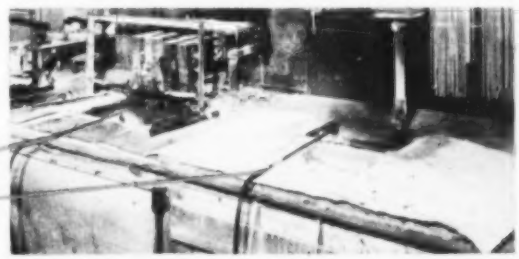


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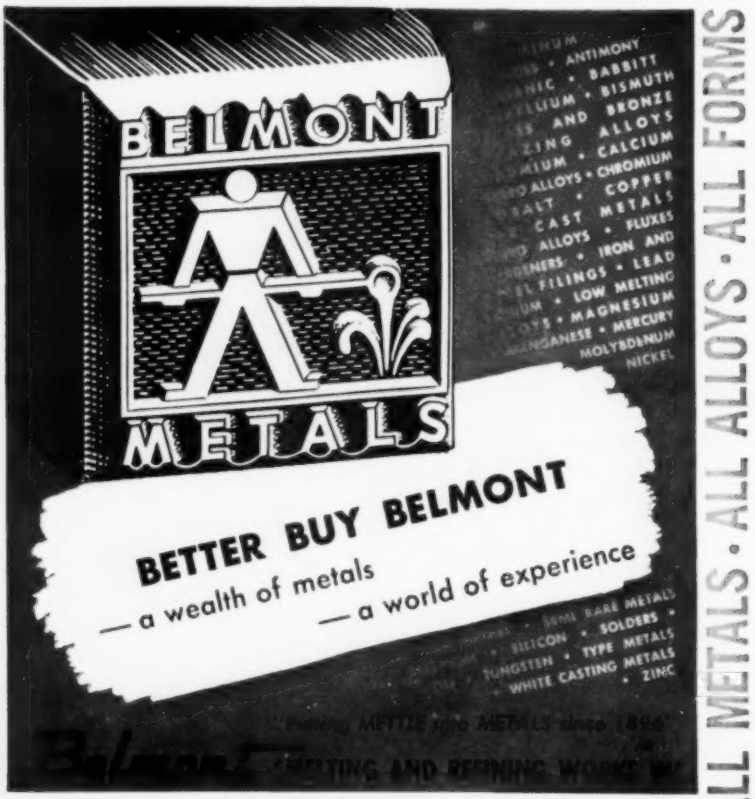


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Effect of Pearlite Spacing on the Transition Temperature of steel

(Continued from p. 268)

(In the reviewer's opinion, the conclusions based on the 20 ft-lb. criterion would not be valid inasmuch as the various pearlites have different impact-energy levels whose difference is maintained uniformly with decreasing temperature. This would indicate that with the 20 ft-lb. criterion there is also no change in transition temperature with pearlite spacing.)

The effect of quenching temperature or transition temperature observed in the 0.20 and 0.40% carbon steels may be due to differences in percentage of pearlite rather than interlamellar spacing. The effect of pearlite spacing depends upon the method of determining transition temperature.

Tensile and yield strengths, hardness, and reduction of area increased with decreasing interlamellar distance, whereas the elongation was virtually unaffected.

A. H. Rauch

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(Continued on p. 272)

*Digest of "The Application of Shell Molding to the Production of Magnesium Castings," Report PB 111049, published by the U.S. Department of Commerce, Washington 25, D.C.



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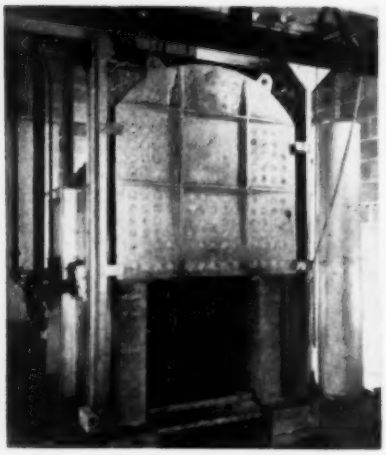
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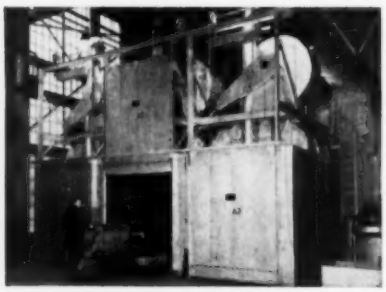
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Shell Molding of Magnesium

(Continued from p. 270)

mold castings of the same part. The tensile properties of shell mold castings were equivalent to the other castings tested.

The mixes for both inhibitor evaluation and core breakdown evaluation were prepared in a laboratory muller. Sand and kerosene as a wetting agent (2 cc. per 1000 g. of sand) were mulled 2 min., after which the resin was added. After 3 min. more of mulling, the inhibitor was added and the mulling continued another 3 min. Satisfactory distribution of resin in the sand was obtained. There was no indication of segregation.

To evaluate inhibitors, about 35 shells were made using a magnesium alloy pattern plate containing a 2-in. cube and a thin-walled cup and small hand pattern plates. Pattern plates were cleaned and lubricated with a silicone compound and then heated in a reverberatory furnace to 400 to 500° F., removed from the furnace and clamped inverted on the dump box containing the sand-resin mix. The dump box was inverted and the mix was in contact with the hot pattern plate for times of 7 to 20 sec., depending on pattern temperature. This resulted in a shell ⅛ to 3/16 in. thick. The dump box was reverted and the pattern with its adhering shell was cured at 400 to 600° F. so as to obtain maximum hardness in the hot cure test.

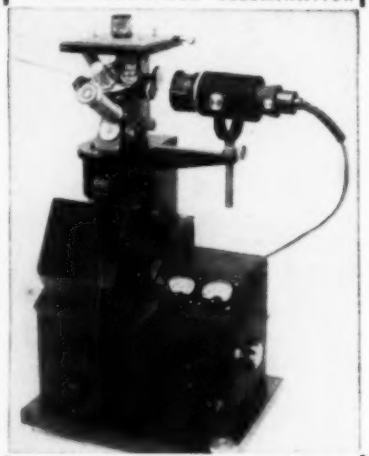
Inhibitor agents were tested as mold washes, mold flushes and shell-mix additions. Mold washes tried were boric acid (H_3BO_3) and Dow No. 181 agent as methanol solutions, and potassium borofluoride (KBF_4) as a weak solution which necessitated shell drying prior to pouring. The mold flushes were made with SO_2, and flushing was carried out by itself and in combination with various washes and additions.

Inhibitor additions to the sand-resin mixes were boric acid, potassium borofluoride, ammonium borofluoride (NH_4BF_4) ammonium fluosilicate ($(NH_4)_2SiF_6$) and ammonium sulphate. Addition agents were introduced in amounts varying from 0.25 to 1% of the mix. Addition agents were also evaluated in various combinations. *(Cont. on p. 276)*

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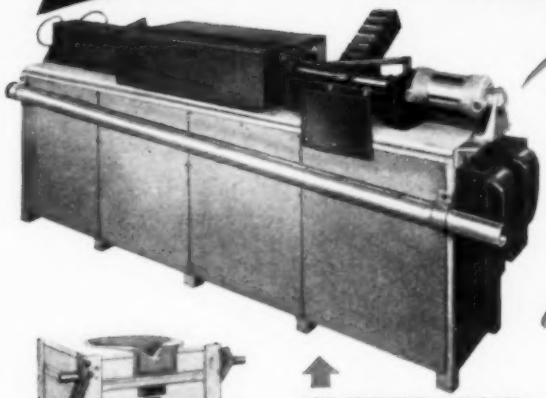
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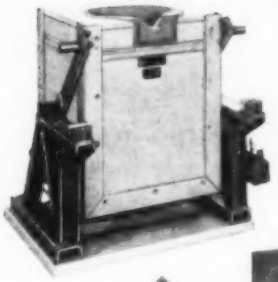
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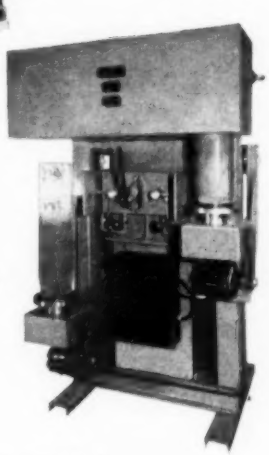


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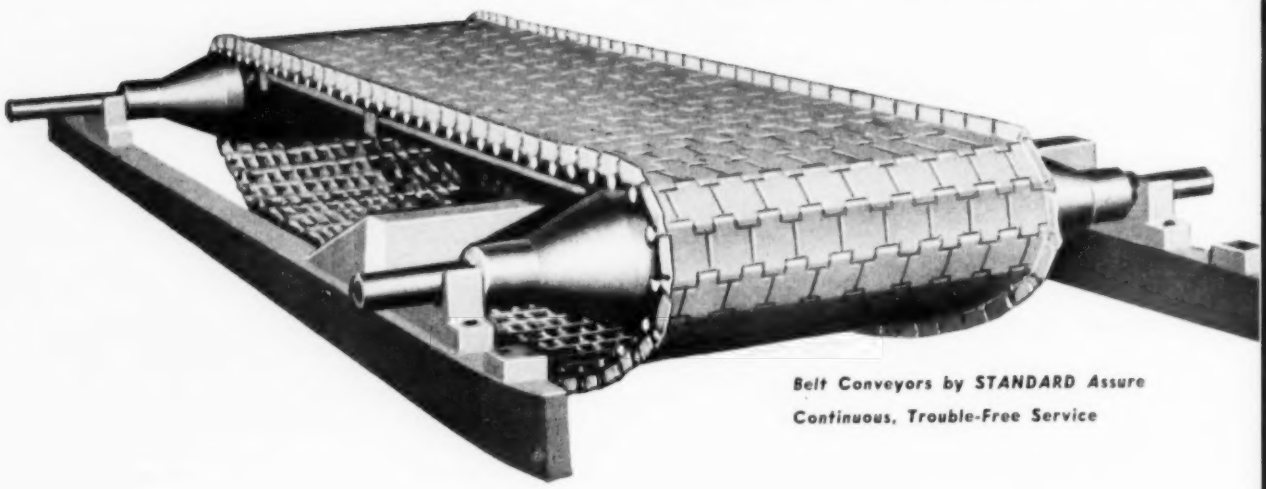
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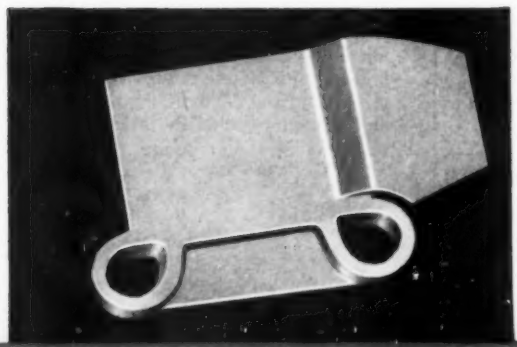


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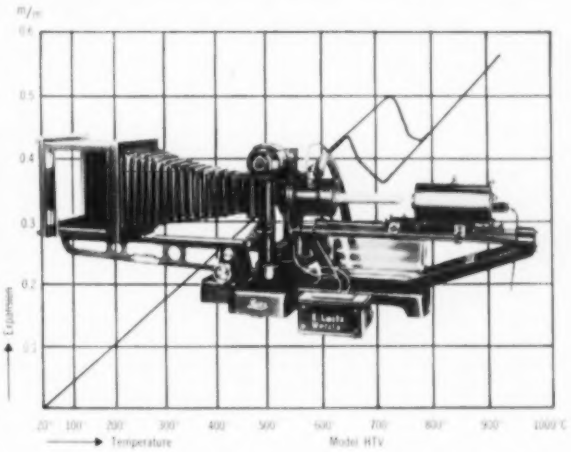


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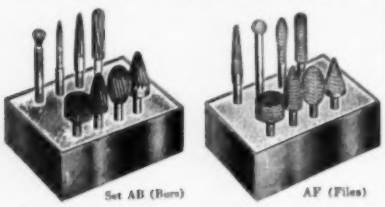
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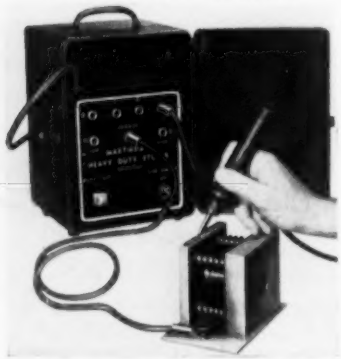
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Shell Molding of Magnesium

(Starts on p. 270)

The inhibitor evaluation tests were made by pouring AZ 92 A alloy (Mg, 9% Al, 2% Zn) at temperatures ranging from 1200 to 1450° F. into the variously washed, flushed or inhibitor-bearing shell molds. Surface color, surface finish, sand adherence and protection from burning were evaluated.

An SO_2 flush of the mold cavity prior to pouring prevented the 2-in. cube from burning but did not inhibit the metal-sand reaction which resulted in surface discoloration and adhering sand. No additional protection was observed when the SO_2 flush was used in conjunction with mold washes and inhibitor additions to the shell mixes.

Of the mold washes, both boric acid and Dow No. 181 agent gave good protection against burning and metal-shell reaction. Potassium borofluoride wash deterred burning but casting surfaces were slightly roughened and discolored. This also was true when it was used as an addition to the sand-resin mix.

All the inhibitors added to the mixes had their characteristic surface discoloration. Ammonium borofluoride gave the most satisfactory results; casting surfaces were discolored but there was no surface roughening as with potassium borofluoride and ammonium fluosilicate. Ammonium sulphate did not inhibit the metal-shell reaction. An addition of 1% boric acid to the mix yielded very good inhibitive results which were, however, nullified by difficulties in shell making.

Because standards were lacking for determining the properties of sand-resin mixes for magnesium castings, tests were designed to measure the hot cure, hot rigidity, transverse strength and permeability of the various mixes. These tests then provided the means for evaluating the usefulness of various sand-resin mixes.

The last problem to be investigated prior to actual shell molding of magnesium alloys was shell-core breakdown. A core blower was designed for making cores for use with shells to produce a thin-walled cup casting. Cores were pasted into shells

(Continued on p. 278)

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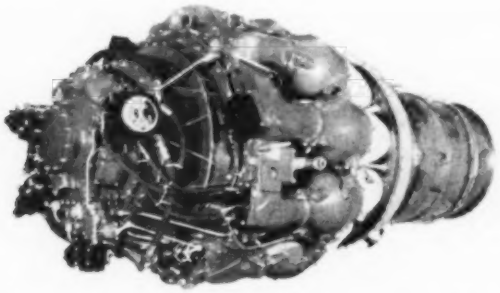
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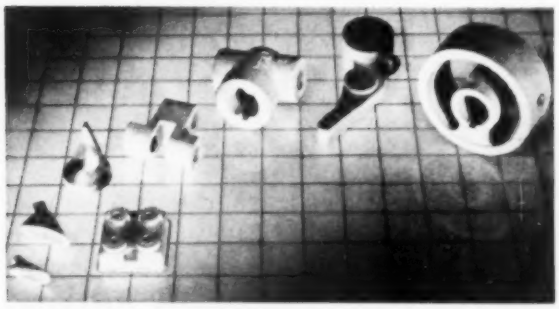
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Shell Molding of Magnesium

(Starts on p. 270)

and poured with AZ 92 A alloy at 1400° F. Various mixes were evaluated to determine ease of shell-core breakdown.

Urea-phenol formaldehyde and furfural-phenol formaldehyde mixes with 3 and 5% resin content proved most satisfactory of those tested. Retained strength was low and they were equal to or better than the core mix normally employed in production which was used as a control in breakdown rating. Other bonding agents tested were phenol formaldehyde-urea formaldehyde, melamine formaldehyde, melamine-urea formaldehyde and an alkyd-type resin.

Finally, the principles developed in these tests were applied to a production casting. Using magnesium alloy pattern plates, shells were made from a mix of 95% silica sand of A.F.S No. 90 fineness, 5% Thor No. 2377-3 resin and ½% added ammonium borofluoride. Cores were bonded with urea formaldehyde resin.

Alloy AZ 92 A, chlorinated and superheated, was poured into the shell mold at 1400° F. Castings were allowed to come to room temperature before being shaken out. Forty minutes after pouring there was still an evolution of noxious fumes from the molds.

Five castings were made and these were solution treated and aged, along with five castings, each of the same part, made in green sand and in permanent molds. The 15 castings were radiographed, test bars were cut and radiographed, and tensile properties were obtained for four bars from each casting.

The tensile values fell into two groups according to location in the castings. On the basis of the higher group of properties, it would appear that the shell-molded castings were appreciably better than the permanent-mold castings and green-sand castings.

On test bars with low properties, radiographic examination revealed porosity. This porosity could be prevented by devoting sufficient time to developing the optimum gates and risers for the castings, but time for this was not available during the test program described. STUART LYMAN

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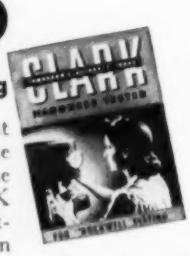
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Extra! Germans Discover Induction Hardened Pinions*

CERTAIN peculiar impressions or prejudices seem to have been handed down from our forebears in America, to judge from the remarks often appearing in the popular press. The best chinaware comes from England (or maybe France)—never from New Jersey. The best woolens come from Scotland—never from New England. The best horses come from Arabia—never from Kentucky. The best steels come from Germany—never from Pennsylvania.

Consequently, it is comforting to the metallurgist to find that in certain processes—such as induction hardening—the German technical press is paying critical attention to operations which have been commonplace for years in America. The article under review is a case in point. An elementary method (hardening each tooth individually) was found to give satisfactory surface hardness, minimum distortion, and good wearing qualities when compared with a conventional method (case hardened or carburized gears). Maybe the Germans will catch up with us after all!

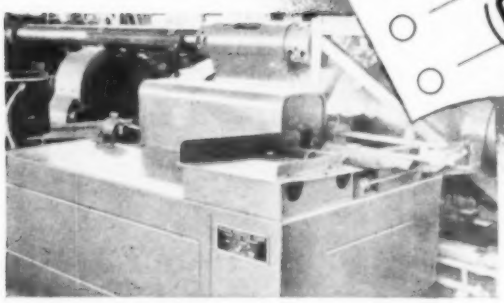
Using small spur gears, a comparison was made between three analyses which were carburized and hardened and four analyses which were induction hardened. Surface hardnesses obtained ranged from Rockwell C-54 to 66 for the induction hardened gears and from C-60 to 64 for the carburized gears. The analyses included both plain carbon steels and alloy steels. Owing to the method of hardening, tooth by tooth, the hardened layer at the roots was very shallow. On the working faces, however, a hard layer of remarkable uniformity, 0.040 in. deep, was produced.

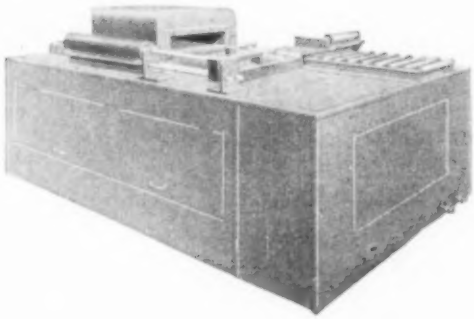
Precise measurements in an optical comparator showed that the induction hardened gears had a negligible distortion after hardening. The endurance limits of the induction hardened gears were found to compare favorably with those of the carburized. The impact strength of

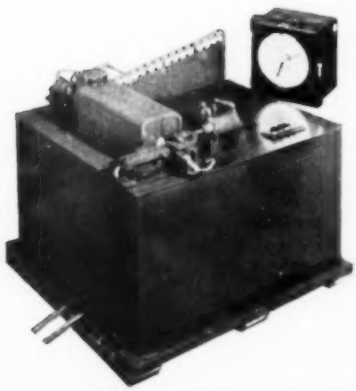
(Continued on p. 282)

*Digest of "Strength and Wear Resistance of Induction Hardened and of Carburized Spur Gears" (in German), by Heinz Glaubitz; *Stahl und Eisen*, Sept. 27, 1951, p. 71.

SOME Practical Information about Low-Frequency (60-cycle) Induction Heating . . .







IS ALL 60-CYCLE HEATING ALIKE?

Sixty-cycle heating is available in a wide variety of forms, each type being suited for a particular application. For instance, a continuous feed heater, one of the less expensive forms, works well on heat treating but is not effective in extrusion where cycling is not consistent and requirements for temperature variation are numerous.

HOW USED?

60-cycle induction heating provides a highly efficient method for heating metals, both ferrous and non-ferrous, for forging, extrusion or annealing. Low-frequency heating has its limitation primarily in the heating of small pieces. For instance, steel bars 4" in diameter and larger can effectively be heated to forging temperature. With aluminum, this figure is reduced to $1\frac{1}{8}$" minimum and with brass to 3". 60-cycle induction heating provides a rapid, highly efficient, clean and economical method for heating metals.

ARE NEW DEVELOPMENTS EXPECTED?

While 60-cycle heating is one of the oldest forms of induction heat, many new developments are being made in the art. Magnethermic's research staff devotes full time to developing new uses and improving present designs. Two recent developments are the large extrusion press heaters for 32" diameter aluminum billets and controlled atmosphere heaters for stainless steel extrusion billets.

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Our company devotes 100% of its efforts to the development, manufacture and sale of low-frequency induction heating equipment. Our plant is a completely integrated operation, having manufacturing facilities, a complete development laboratory, sales and engineering offices. Our departments are staffed by men whose primary interest is low-frequency induction heating equipment. Each is a specialist in his particular branch.

We invite your inquiry on any special heating problem that you may have.

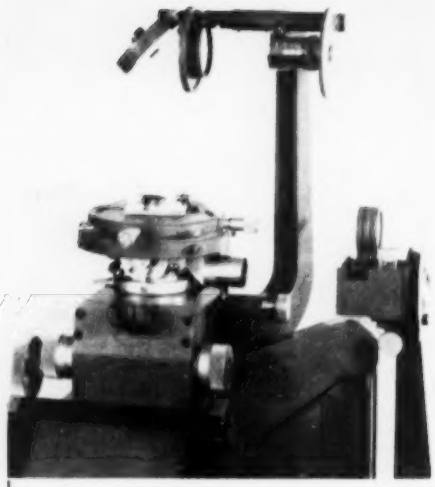
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Induction Hardened Pinions

(Continued from p. 280)

the teeth was also found to be greater than that of the carburized. Also, the variations in the static breaking load and in the impact values were found to be less for the induction hardened than for the carburized gears. (The impact values in all specimens were found to vary more from tooth to tooth than did the static breaking load of the teeth, a result which confirmed earlier investigations.) Development of pits or flaked surface during progressively heavier impact loads occurred at a later period in the test on induction hardened than on carburized gears.

Wear tests showed that the rate of wear was of the same order of magnitude for both induction hardening and carburizing.

The results were taken to indicate that induction hardening and case hardening can compete with each other in this type of gear at the present level of technical development in Germany.

This conclusion is probably valid, although it is based on a rather small number of samples. The induction machine used for the hardening had a small output, necessitating hardening of each tooth individually, and the carburized gears, which were apparently pack carburized, had a greater variation in case between crest and root than would be considered normal in current American carburizing practice.

Analysis and Correlation of Test Data

(Continued from p. 118)

in this article is the family of techniques known as "single" and "sequential sampling". Basically, we decide beforehand what quality performance will be regarded as satisfactory and what as unsatisfactory. Then we decide upon the risks or probabilities of *(a)* rejection of a lot, process or technique at the satisfactory level, and *(b)* acceptance at the unsatisfactory level. Given these four facts—two levels of performance and two risks of wrong decisions—a sampling plan can usually be chosen which will provide the desired pro-

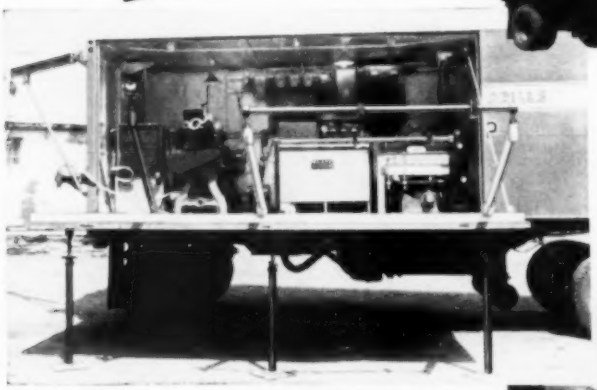
(Continued on p. 284)

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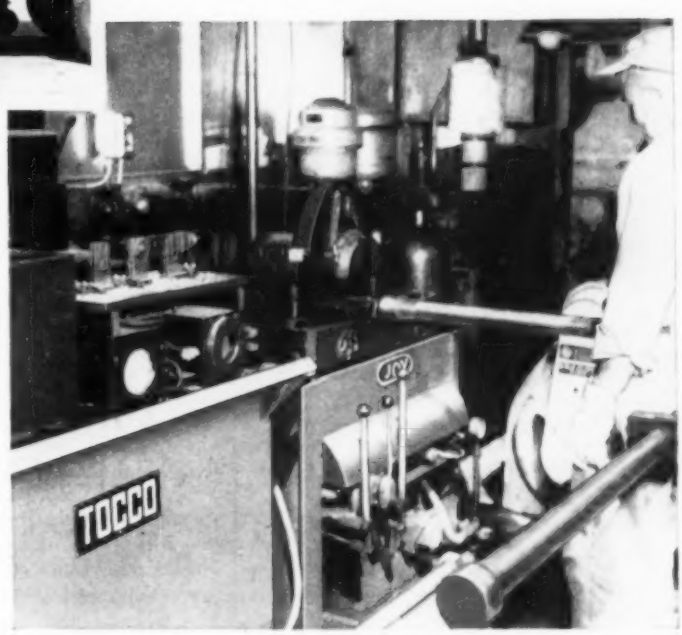
Joy Manufacturing Company's Mobile Shop for on-location reconditioning of mine drill steels.

BECAUSE of the size and length of mine drill steels, (some weigh as much as 320 lbs. and are 30 ft. long) much expense and lost time was involved in shipping them back to the factory for reconditioning. Realizing this problem, Joy Manufacturing Co., Pittsburgh, Pa., decided to send "Mohammed to the mountain" in the form of the *Joy Mobile Shop.*

The purpose of the Mobile Shop is to travel to designated territories in the United States, calling periodically on users of Joy's "Challenger" Drill. All broken drill steels are reconditioned on the spot—saving Joy's customers transportation costs and lost time.

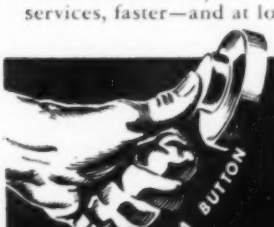
The Joy Mobile Shop carries a 20 KW, 10000 cycle TOCCO Induction Heating machine, powered by a diesel-electric generator. The TOCCO unit heats the drill steels to 2200° F for upsetting, then reheats the upset ends to 1500° F for normalizing prior to machining.

This unusual application story is typical of the way TOCCO engineers team up with American Industry for better products and services, faster—and at lower cost.



Operator guiding drill steel in upsetter after heating end to 2200° F in TOCCO machine at left.

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Analysis and Correlation of Test Data

(Starts on p. 112)

tection against wrong decisions. The plan could be single sampling, in which a decision for acceptance or rejection is automatically reached after a specified number of tests or measurements. Or the plan could be sequential sampling, in which we might decide to accept, or reject, or request more data after each test or measurement. Thus, the sample size is variable.

The advantage of sequential sampling is that it requires considerably smaller *average* sample sizes than does single sampling for the same degree of protection. This is an important consideration where each measurement or test may be costly. Single sampling, however, is usually easier to calculate, to teach and to administer. In any practical case, there is the choice between the two.

The methods described above will handle a very good proportion of industrial problems of a statistical nature. There are, however, other techniques which can be brought in to help the metallurgist, when necessary. The big thing to remember is: If you have random variation in your problem, then there is some statistical tool which can help you analyze your data and help you make sound decisions. Get acquainted with the methods and make use of them.

A Test for Age Hardenability*

IT IS WELL KNOWN that brittle fractures—often with disastrous results—have occurred in welded structures, yet the metal showed good ductility when tested in tension, bending or impact after the failure. This is true of metal specimens cut from locations as near as possible to the brittle fracture. The usual (and plausible) conclusion is that the fracture without plastic deformation was caused by the stress system existing at the time of failure—that is to say, multi-axial stresses (such as three-

(Continued on p. 286)

★Digest of "A New Notched-Bar Impact Test" (in German), by Roland Mitsche; *Berg- und Huttenmannische Monatshefte*, Vol. 97, April 1952, p. 72.

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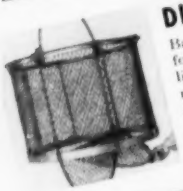
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A Test for Age Hardenability

(Continued from p. 284)

dimensional tension) held the metal rigidly in such a manner that it could not flow slightly and plastically as required by "tough" or "non-brittle" action.

This is doubtless an oversimplification of the situation. It should not prevent a search for metals which have higher resistance to such stress systems. It should not prevent a search for causes which may convert a satisfactory steel—in the respect just mentioned—into an unsatisfactory steel. One of the latter influences appears to be "mechanical aging"—gradual hardening with time at room temperature of portions of the steel which have endured a certain amount of cold deformation during fabrication. This phenomenon is especially prominent in basic bessemer (Thomas) steel.

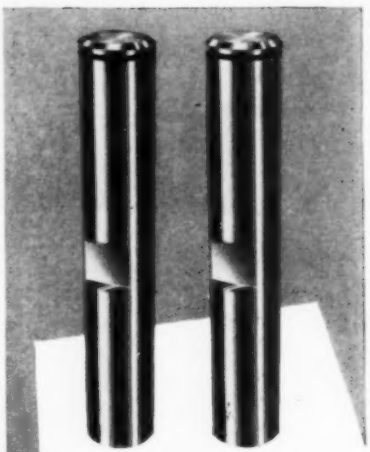
To study this tendency, Professor Mitsche suggests a special testpiece. At least it can separate steels into two classifications: (*a*) "practically insensible" to mechanical aging, and (*b*) "sensible" to mechanical aging—and therefore to be excluded from rigid structures.

The specimen starts as a small square bar 10x10x55 mm. in size, corresponding to the International Standard Charpy testpiece. Instead of machining the notch in it, the notch is cold forged in the following way: A hardened block is attached to the anvil of the Charpy machine whose outer edge is shaped like the V-notch. The square testpiece is then attached to the hammer in such a way that when a blow of given energy is delivered, the energy is absorbed in forcing a V-notch into the testpiece at its midlength.

A series of such testpieces may be prepared and tested in the ordinary way after having been aged for definite times at definite temperatures. Results, when compared with samples of the same steel with the same history, except having machined notches, will appraise it as to its "sensibility" as above defined.

Results so far obtained indicate that one cannot predict the results of any program of aging, either artificial or natural, from the results of some other program.

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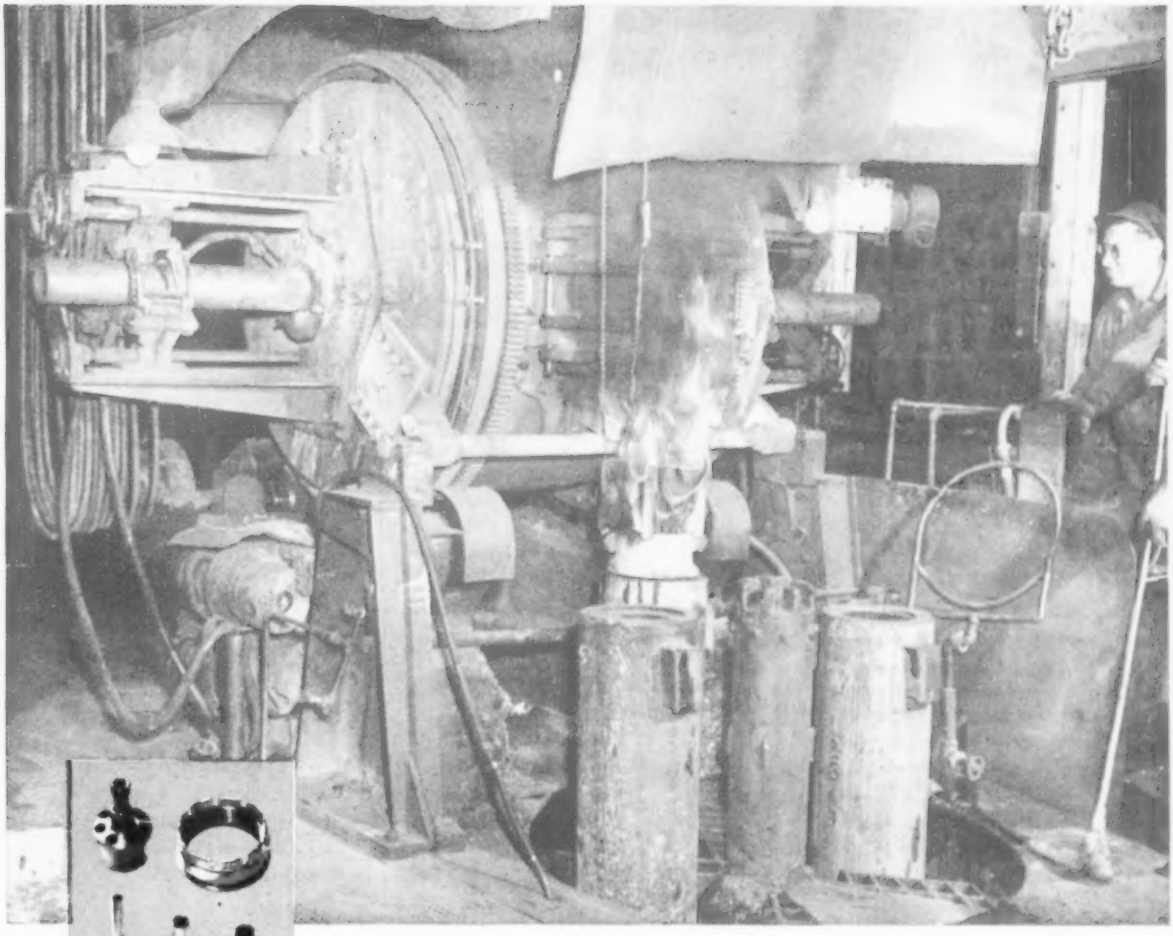
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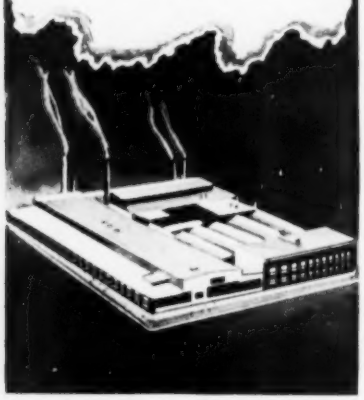
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Effect of Rolling Direction, Straining and Aging on Properties of Mild Steel Plate*

A study of the combined influence of rolling mill fiber, straining in the direction of rolling and transverse to the direction of rolling, plus aging treatments after hot rolling and cold straining, on the tensile and impact properties of hot rolled plate steel of commercial quality is described in this paper. In addition, the determination of the transition temperature, at which the impact fracture changes from the tough, fibrous type to the cleavage or crystalline type was observed. The material investigated was a standard plate steel of the following analysis:

Carbon	0.12%
Silicon	0.02
Manganese	0.48
Phosphorus	0.019
Sulphur	0.037
Nickel	0.14
Molybdenum	0.03
Tungsten	0.02
Vanadium	0.02
Aluminum	0.005
Copper	0.12
Nitrogen	0.007

Test pieces of the ½-in. plate were cut 18 in. long and 3 in. wide in both the longitudinal and transverse direction. The test pieces were marked in 2-in. lengths by fine scribed lines and were then strained until the yield point was passed, the total strain amounting to 3.75% after removal of the load. Two other test pieces were given a total strain of 10% in order to observe the effect of larger amounts of strain. The variation in strain over successive 2-in. gage lengths was within 0.5%, indicating a fairly uniform degree of strain over most of the specimen length. The uniformly strained portions of the samples were then machined into test pieces as follows: Single-notch Izod impact specimens of standard dimensions were cut in the direction of straining and transverse to it. The notch was machined perpendicular to the plane of the

(Continued on p. 290)

★Digest of "Effect of Direction of Rolling, Direction of Straining, and Aging on the Mechanical Properties of Mild Steel Plate," by C. A. Tipper; *Journal* of the Iron and Steel Institute, Vol. 172, October 1952, p. 143.

short run stampings



DESCRIBED IN NEW CATALOG No. 718

New catalog describes HPL's "know-how" which can save up to 80% of conventional tooling costs.

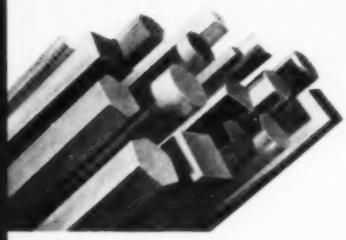
Facilities for producing stampings in runs of 25 to 25,000 pieces in various shapes and materials are described and shown. **HPL** is making this attractive four-page catalog available to production, purchasing and management personnel to assist them with their stamping problems. Catalog No. 718 will be sent to you upon receipt of publication or letterhead request.



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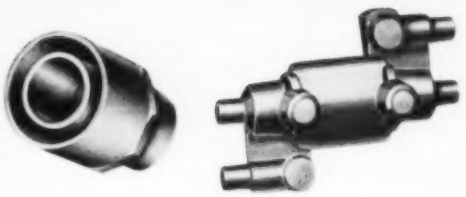
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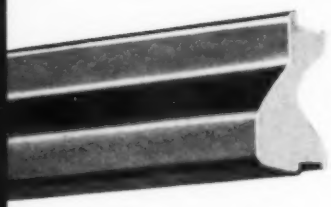
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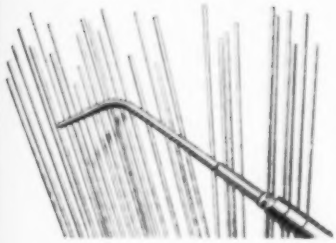
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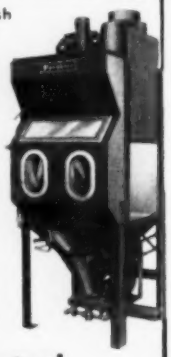
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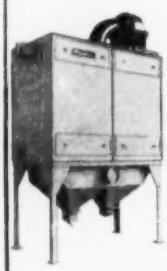
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Properties of Mild Steel Plate

(Continued from p. 288)

plate. Hounsfield tensile test specimens, 0.25-in. diameter, were made so that on subsequent testing they would be extended in the same direction as the original bar was pulled, and also transverse.

The system of marking the specimens was as follows: L for large test piece cut in direction of rolling; X for large test piece cut transverse to direction of rolling. If the small test piece was cut so that its long axis was in the direction of straining of the large test piece, it was designated by l, and if cut perpendicular to this direction, by x. Hence Ll indicates that the material was strained in the direction of rolling and the test sample was cut in the direction of straining.

The finished test pieces were boiled for 15 min. before testing. Other samples were given a further aging treatment at 250° C. (480° F.). The results of the impact tests are given in the tabulation alongside.

(Continued on p. 292)

Sample Ref. No.	Temp. °F.	Izod Ft.-Lb.	Fracture % Crystalline
Ll	−40	3	C*
Ll	−22	5	C
Ll	−4	4	C
Ll	14	9	90
Ll	32	18	90
Ll	39	24	80
Ll	43	24	75
Ll	46	77	F†
Ll	57	72	F
Lx	−4	8.5	90
Lx	14	15	90
Lx	32	19	75
Lx	48	22	60
Lx	64	27.34	40F‡
Xl	−40	2	C
Xl	−4	6	C
Xl	28	15	80
Xl	41	20	75
Xl	68	33	F§
Xl	95	38	F
Xl	104	34	F
Xl	122	33	F
Xx	−22	4	C
Xx	14	20	90
Xx	32	17	90
Xx	54	75	F
Xx	86	74	F

* Crystalline; † Fibrous; ‡ with patch crystalline material; § with specks crystalline.

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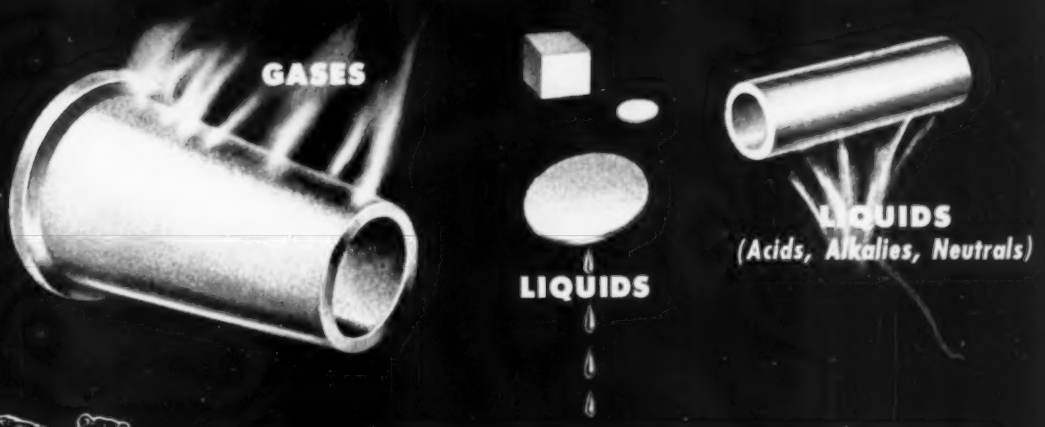
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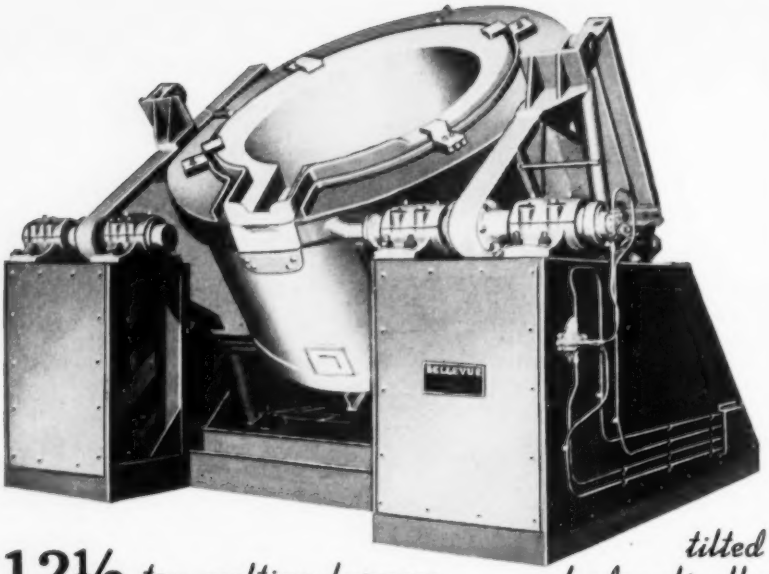


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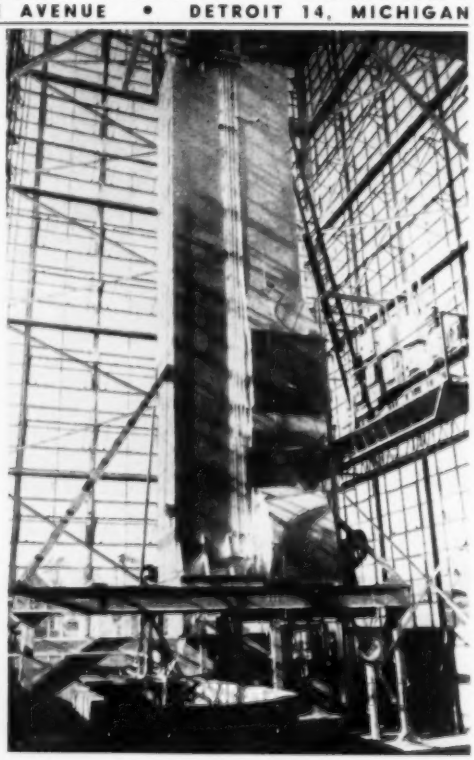
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Properties of Mild Steel Plate

(Continued from p. 290)

It will be noted that the direction of rolling has a marked effect on the impact tests while the direction of straining seems to have little influence on these results. The transition temperature from fibrous to brittle fracture seems to be about the same, regardless of either the direction of rolling or straining. The transition temperature thus seems to be an inherent property of the steel which is unaffected by the manufacturing or test preparations involved in this research.

The tensile tests show little effect from the direction of rolling, except for the values for reduction of area which are consistently high in the longitudinal direction compared with the transverse, irrespective of the variation of the other values. Yield point, ultimate strength and elongation are all affected by the direction of straining and aging treatment. The tensile tests show a very large influence of the direction of straining on the yield stress. The transverse yield strength of the hot rolled plate is practically the same as the longitudinal yield, but the values after 3.75% cold straining are 48,200 psi. in the L1 direction compared to 36,100 psi. in the Lx direction; 47,300 psi. in the X1 direction; and 34,300 psi. in the Xx direction. The large influence of the transverse prestraining is noteworthy and there is no plausible explanation. This difference, only removed after heating to 1200° F., is said to be too large to be due to the Bauschinger effect. Moreover, the mechanism that has been suggested to explain recovery of a yield after straining by migration of carbon or nitrogen does not admit a directional effect of this nature. Yet the connection between the characteristic yield in mild steel, aging, and the presence of carbon and nitrogen is corroborated by so much experimental evidence as to be undisputed.

Other workers have postulated that this effect on yield strength may be due to the formation of microcracks on the first straining. It is difficult, however, to reconcile the small increase in tensile strength after straining with the presence of such microcracks. E. C. WRIGHT

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Summary of Knowledge of Preheating and Postheating Effects on Weld Quality*

Preheating and postheating techniques make it possible to fabricate successfully certain base metals into weldments which would not otherwise be economically practicable. In general, correct preheating practice helps fabrication in the following ways:

1. Prevents formation of cracks in the weld or heat affected zone.
2. Reduces distortion.
3. Prevents loss of ductility and toughness in the weld or heat affected zone.

In general, the degree of preheating required increases with the section thickness or carbon and alloy content of the base metal. General recommendations for preheating and postheating treatments are given in the accompanying tabulation. It should be noted that the use of Exx15 or Exx16 electrodes, which are designed to prevent underbead base metal cracking, does not eliminate the need for preheating to reduce distortion, or to avoid loss of ductility in the heat affected zone.

In general, postheating is used for two principal reasons:

1. To reduce residual stresses to a low level.
2. To soften and toughen the heat affected zone.

Stress-relieving, a form of postheat treatment, is applied to weldments to obtain dimensional stability during machining operations and in service. As the sectional thickness and carbon and alloy content of the base metal increase, the importance

(Continued on p. 296)

*Digest of "The Preheating and Postheating of Pressure Vessel Steels", by R. D. Stout, *Welding Research Supplement*, January 1953, p. 14s-22s.

Recommendations for Preheating and Postheating Pressure Vessel Steels

Carbon Range, Percentage	Thickness, In.	Min. Preheat and Interpass Temp., °F.	Postheat Temp., °F.
		Carbon Steels	
Under 0.25	Up to 1	None	None
	1 to 2	100 or E6015-16	1100-1250 d*
	2 to 4	200	1100-1250 d
0.25 to 0.30	Up to ½	None	None
	½ to 1	100 or E6015-16	1100-1250 d
	1 to 2	200 or E6015-16	1100-1250 d
	2 to 4	300 or 100 with E6015-16	1100-1250 d
0.31 to 0.35	Up to ½	100 or E6015-16	1100-1250 r†
	½ to 1	200 or E6015-16	1100-1250 r
	1 to 2	300 or 100 with E6015-16	1100-1250 r
	2 to 4	300	1100-1250 r
		High-Tensile Alloy Steels	
Under 0.15	Up to ½	None	None
	½ to 1	100 or Exx15-16	1100-1250 d
	1 to 2	200 or Exx15-16	1100-1250 r
	2 to 4	300 or 100 with Exx15-16	1100-1250 r
0.16 to 0.20	Up to ½	100 or Exx15-16	1100-1250 d
	½ to 1	200 or Exx15-16	1100-1250 d
	1 to 2	300 or 100 with Exx15-16	1100-1250 r
	2 to 4	300 or 200 with Exx15-16	1100-1250 r
0.21 to 0.25	Up to ½	200 or Exx15-16	1100-1250 d
	½ to 1	300 or 100 with Exx15-16	1100-1250 r
	1 to 2	300	1100-1250 r
0.26 to 0.31	Up to ½	300 or 100 with Exx15-16	1100-1250 r
	½ to 1	300 or 200 with Exx15-16	1100-1250 r
	1 to 2	300	1100-1250 r
		Nickel Steels	
Under 0.15	Up to 1	300 or 100 with Exx15-16	1100-1250 r
	1 to 4	300 or 200 with Exx15-16	1100-1250 r
0.16 to 0.21	Up to ½	300 or 100 with Exx15-16	1100-1250 r
	½ to 1	300 or 200 with Exx15-16	1100-1250 r
	1 to 4	300	1100-1250 r
0.22 to 0.27	Up to ½	300 or 200 with Exx15-16	1100-1250 r
	½ to 1	300	1100-1250 r
	1 to 4	400	1100-1250 r

*Desirable. †Required.

Summary of Preheating and Postheating

(Continued from p. 295)

of proper postheating technique increases.

To some extent, preheating and postheating are equivalent in their influence on the heat affected zone. Both tend to promote a softer, tougher heat affected zone. However, both have their limitations. The preheat temperature must be relatively high in order to have much effect on residual stresses or to prevent hardening in this zone in highly hardenable steels. Postheating is of little help in prevention of cracking, unless applied before the weld cools down; sometimes it is injurious to strength characteristics.

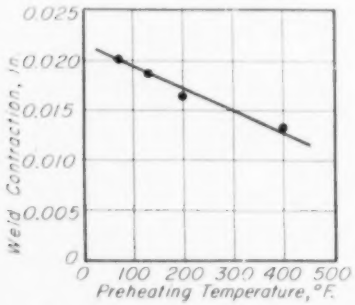


Fig. 1—Effect of Preheating on the Transverse Contraction of Weld (Measured Over 1-in. Gage Length Across Weld Groove)

The major effect of preheating is to reduce the thermal gradient between weld and base metal and thus retard the cooling rate. This is most important in two temperature ranges: *(a)* Between 1300 and 600° F., which is the austenitic transformation range; *(b)* between 400° F. and room temperature, which is the range of formation of microcracks in the weld metal and heat affected zone. By lowering the cooling rate, the amount of contraction of the weld is reduced, as shown by Fig. 1. Also, the ductility and toughness of the heat affected zone are improved, as shown by Fig. 2.

The major effect of postheating is the relief of residual stresses by depressing the yield strength of the base metal while hot so that plastic yielding occurs. Since alloying elements such as molybdenum, tungsten, chromium and vanadium increase the high-temperature strength of steel, these alloys require higher postheating temperatures for effective stress-relief. It is usually more economical to use a postheat temperature high enough to accomplish stress-relief in one or two hours of holding time.

With reference to the effect of re-

(Continued to p. 298)

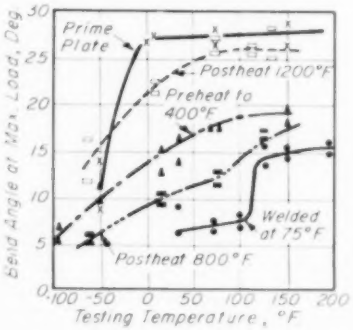


Fig. 2—Effect of Preheating and Postheating on Longitudinal Notch-Toughness of 0.25% C Steel. Samples were 3/4-in. plate (silicon-killed) and welded with 3/16-in. diameter E6010 electrode at 10 in. per min. using 175 amp.

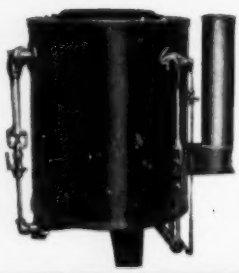
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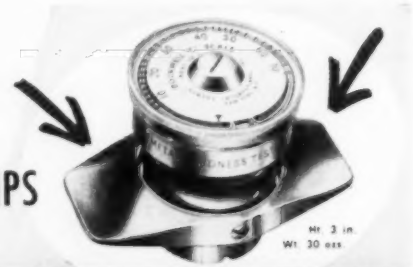


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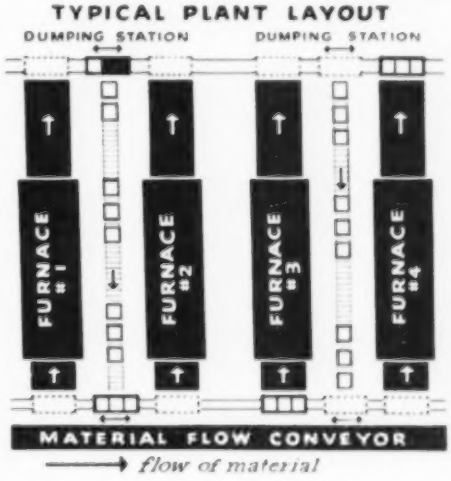
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Summary of Knowledge of Preheating and Postheating

(Continued from p. 296)

sidual stresses on notch-toughness, the evidence is conflicting. Even a small amount of ductility will permit some plastic flow under a load exceeding the yield strength and thus relieve the residual stress peaks. Only a few tenths of 1% strain are required to accomplish relief. Therefore residual stresses can cause premature failure only in a region of the weldment which is totally brittle.

The effect of postheating on the notch-toughness of welded plain carbon steel is progressive as the temperature is increased, as shown in Fig. 2. However, some of the high-tensile weld metals are embrittled by postheating in the usual range of stress-relieving. Postheating in the range of 500 to 800°F. is detrimental to cold worked metal. If cold forming precedes welding and postheating is done between 500 and 1000°F., the effect of aging embrittlement may become noticeable.

W. L. WARNER

Effect of Alloying Elements on Creep Rate of Nickel*

THIS INVESTIGATION was undertaken to substantiate that a relationship exists between strain and time, a proposal which had been advanced by the authors on the basis of previous work and also by others. This relationship may be expressed:

$$\epsilon - \epsilon_o = At^b$$

where ϵ = total true strain

ϵ_o = instantaneous strain of moment of loading

t = time

A, b = constants

Pure nickel and solid solution alloy systems of nickel with cobalt, iron, titanium, and tungsten were considered in the present work. All creep tests were confined to 700° C. (1290° F.) and 5750 psi., and were continued for short-time periods of 40 to 120 hr.

It was found that the creep rate of nickel decreased progressively as the iron content was raised to 10%, the titanium to 2.00%, and the tungsten to 1.0%. Consistent trends were not obtained with the Ni-Co alloys.

On the basis of the limited test data, it was found that the expression $\epsilon - \epsilon_o = At^b$ accurately describes the constant-stress creep curves for the alloy systems considered, and that the three creep parameters varied as follows:

Parameter A decreases exponentially as the alloy content increases.

Parameter B increases directly as the alloy content increases.

Parameter ϵ_o decreases directly as the alloy content increases.

Neither of these parameters, by itself, reveals the true creep resistance because each varies at an entirely different rate. The authors believe the best indication of the creep resistance is given by the product of $A \times B$. The authors were not able to find a relationship between creep resistance and the lattice constants, but postulate that one may exist with certain other material constants of the alloys.

(Continued on p. 300)

*Digest of "Effect of Some Solid Solution Alloying Elements on the Creep Parameter of Nickel", by T. H. Hazlett and E. R. Parker, © 1953 Preprint No. 38.

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Creep Rate of Nickel

(Continued from p. 298)

It should be recognized that, for the given conditions of temperature, stress and time, all of the creep curves obtained are still in the so-called first stage of creep; that is, the creep rate is decreasing fairly rapidly with time. For most commercial applications, interest lies in tests of much longer duration and lower and more constant creep rates. The question then arises as to whether the authors' conclusions would apply to such conditions.

C. L. CLARK

Casting Brass Ingots and Billets*

THIS CONTRIBUTION is a part of a symposium on the control of quality in the production of wrought nonferrous metals and alloys; it deals with principles underlying the production of high-quality wrought copper alloys and is a very careful description thereof. Other important details of actual operation are also included. The alloys discussed are the straight copper-zinc alloys containing from 3 to 43% zinc; the more important copper-zinc alloys with relatively small amounts of lead, tin, aluminum; and the nickel-silvers. A standard is set up regarding the quality that must be maintained in the cast ingots and billets if the wrought products that are made from these are to meet the customer's requirements. The care taken to eliminate or avoid imperfection in the castings should result in the final analysis in a lowering of production cost.

Quality control starts with the raw materials, since the presence of impurities may most adversely affect the finished product. For example, lead in alpha brasses may, for the purpose of cold rolling, be present to the extent of 0.07%; for hot rolling, not more than 0.02% is permissible. Scrap must be segregated carefully. Purchased scrap, the history of which is not known, is said to be the greatest hazard in making up correct furnace charges. If purchased scrap is unduly heterogeneous, it should be melted into ingots, the composition of which can be ascertained by analysis. Baled scrap is tested by passing the bales through a coil carrying direct current, an indication of the amount of iron present being obtained by a measurement of electromotive force set up in a second coil which is concentric with the first.

Low-frequency electric furnaces are generally used for melting brass for ingots and billets. Furnaces are charged first with medium scrap followed by copper and light scrap and then heavier scrap. Zinc is added at the end of the melting cycle. The nickel, tin, and aluminum are added as virgin metals about three quarters of the way through the melting cycle. Lead is added as a 50-50 copper-lead alloy. It is not recommended that iron be added as such (since segregation of iron constituents is likely to occur in the cast product); copper-iron or zinc-iron having 5 to 10% iron should be used. Manganese, phosphorus and silicon are added as copper alloys of 30, 5 to 15, and 10%, respectively. Arsenic and antimony are added in

(Continued on p. 302)

*Digest of "The Control of Quality in the Production of Brass Ingots and Billets," by Maurice Cook and C. L. M. Cowley, *Journal* of the Institute of Metals, Vol. 81, March 1953, p. 341-350.

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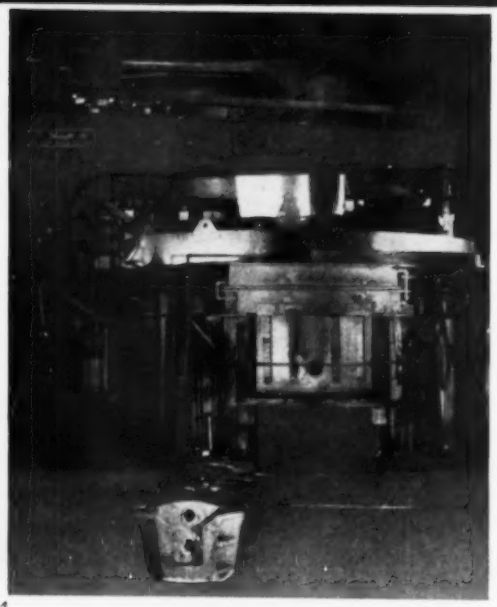
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Casting Brass Ingots and Billets

(Continued from p. 300)

finely divided form just before pouring. Charcoal in stick form is used as a cover, a layer 2 in. thick being maintained.

The dross formed of unburnt charcoal and metallic oxides (mainly zinc), together with particles of entrapped metal, builds up on the surface of the melt; to reduce the metallic content, common salt—in amounts of 1 to 4 lb. per 1000 lb. of melt—is added as a flux. To avoid iron contamination, iron stirrers should be fitted with sheaths made of lead.

With high zinc content no degassing is needed; nickel alloys are liable to this defect, and treatment with Walpole flux is advised. Fifteen minutes before pouring, the charcoal cover is entirely removed and the metal allowed to oxidize for about 10 min., after which fresh charcoal is added. Immediately before pouring, cupro-manganese is added as a deoxidizer and well stirred into the melt. The charcoal cover is left on during pouring to avoid reoxidation. Analytical control is rigidly maintained, particularly where copper is concerned.

The importance of using the correct casting temperature is stressed, as when this falls below the optimum, entrapped splashings and oxides on surface may develop; temperatures above the optimum cause central unsoundness due to shrinkage and a coarser structure. Casting temperatures are given for some twenty alloys. Control should be within ±15°F. The sensitiveness of the 66 to 67% copper in the copper-zinc series is stressed. This alloy develops a small amount of beta phase at the temperatures used in rolling which tends to segregate at the grain boundaries of the large crystals and cause severe cracking during the hot rolling. If the casting conditions have resulted in small equiaxed crystals, the beta phase is then generally distributed in the form of small particles and the alloy will hot roll satisfactorily.

A detailed statement is made regarding molds. Both cast iron and water-cooled molds are used, the former for rolling slabs of relatively small section, these being used for cold rolling and the extrusion of billets. Copper-faced molds are used mainly for slabs of relatively large section for hot rolling, although increasing interest is being shown in their use for billet casting. The wear of iron molds may be such as to cause hot tears. This is emphasized when copper-nickel alloys or nickel-silvers are poured, the higher pouring temperature increasing the attack. In the cooled molds of copper for 1000-lb. brass slabs, water is circulated through the mold at 100 gal. per min., the temperature being maintained at about 70°F. Uneven distribution of the cooling water must be avoided.

Mold dressings are important and a table is given which lists alloy composition, form of casting, type of mold, and composition of dressing.

The last item in the article—inspection—pertains to both visual and chemical.

H. J. Roast



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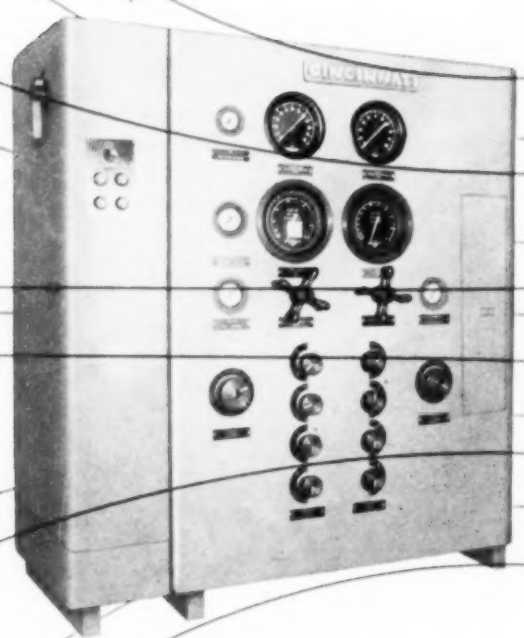
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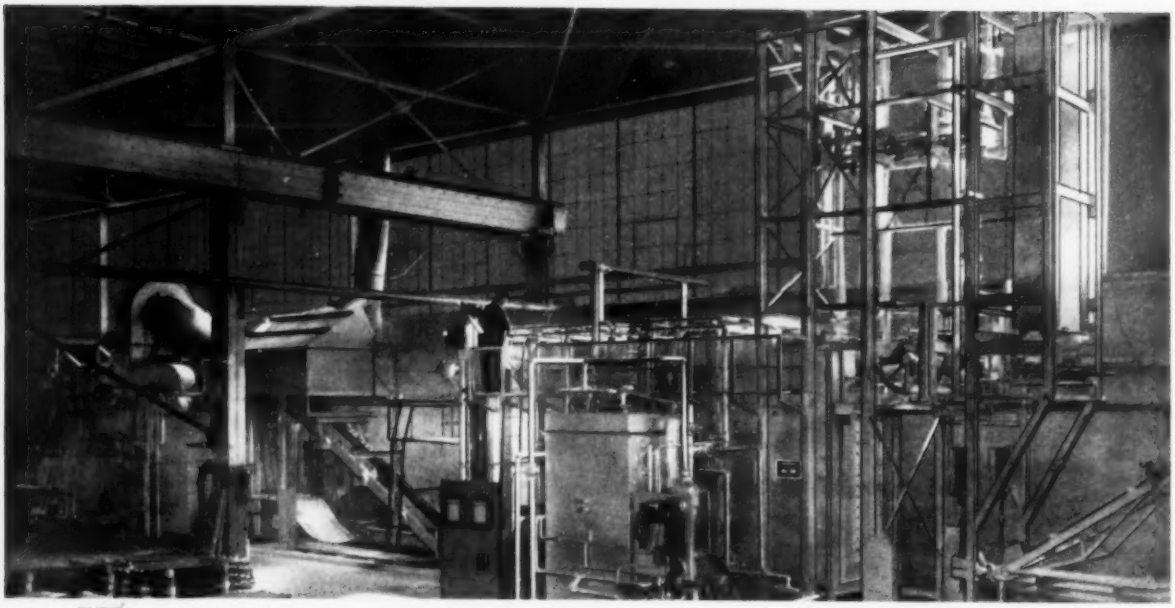
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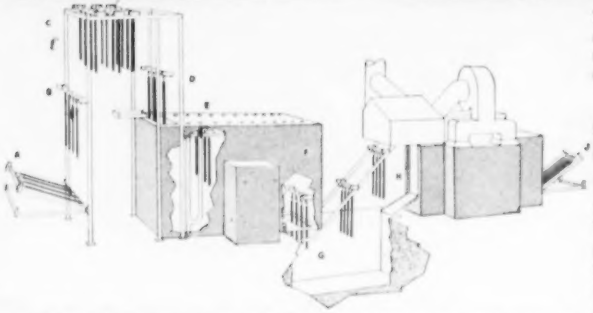
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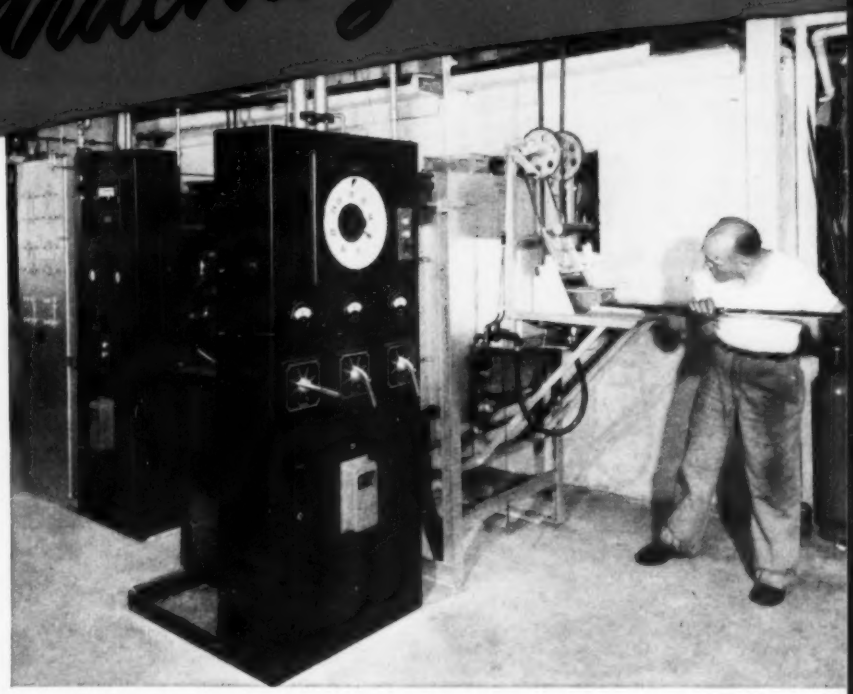
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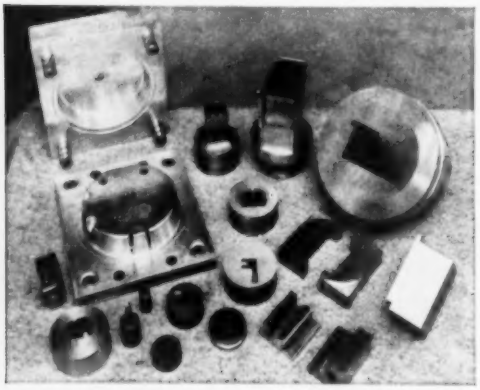
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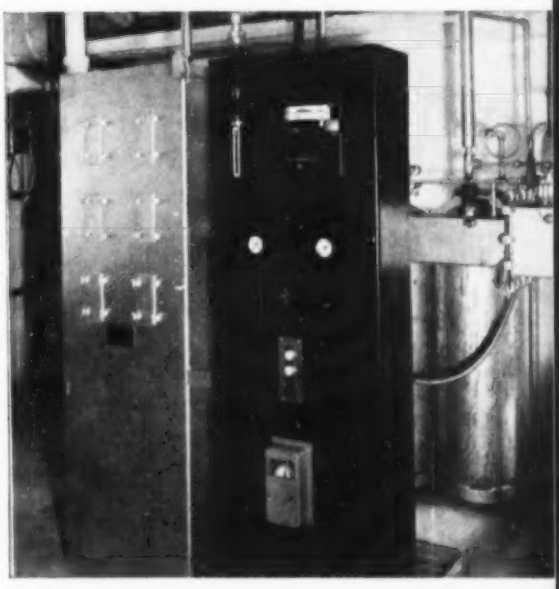
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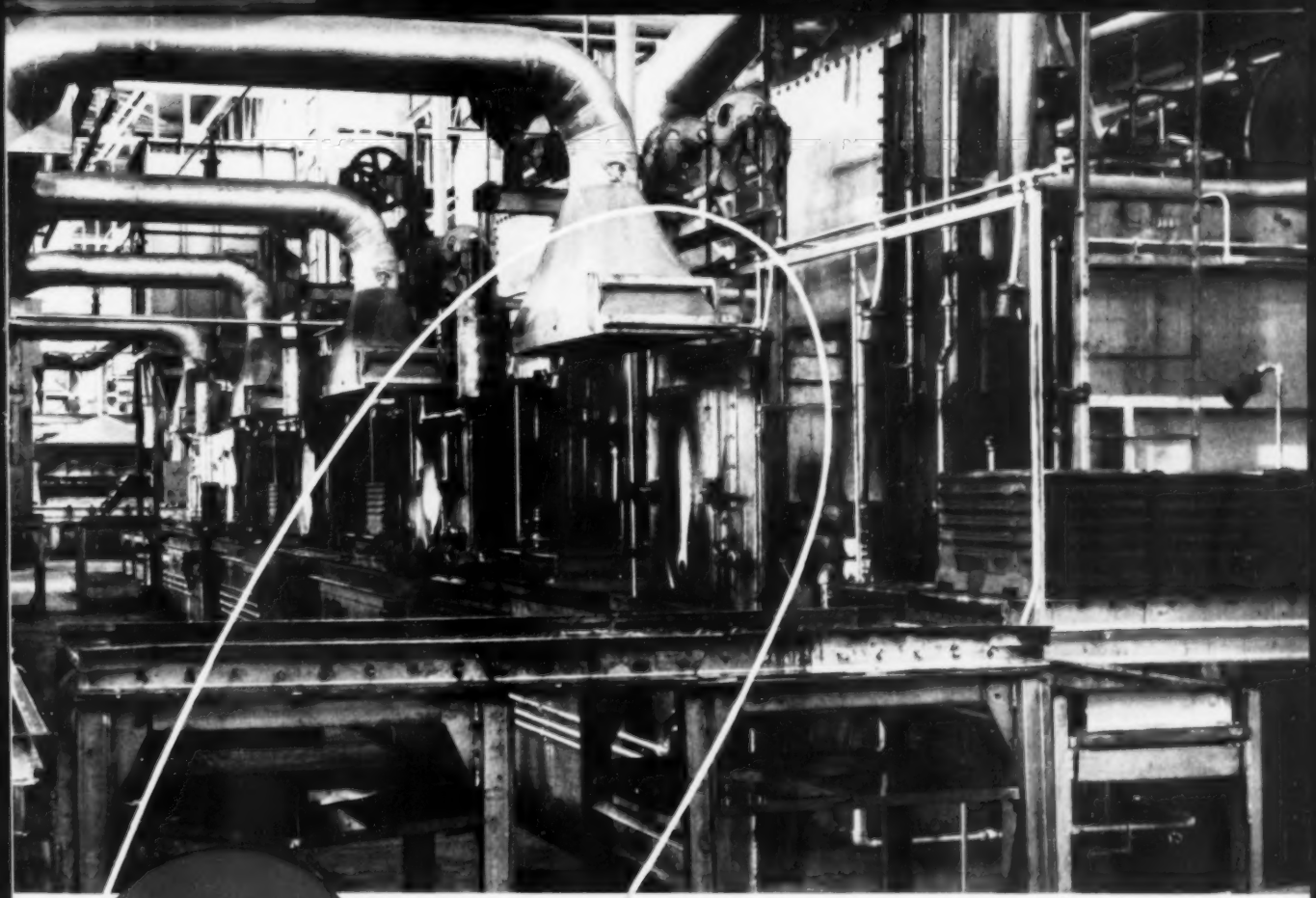
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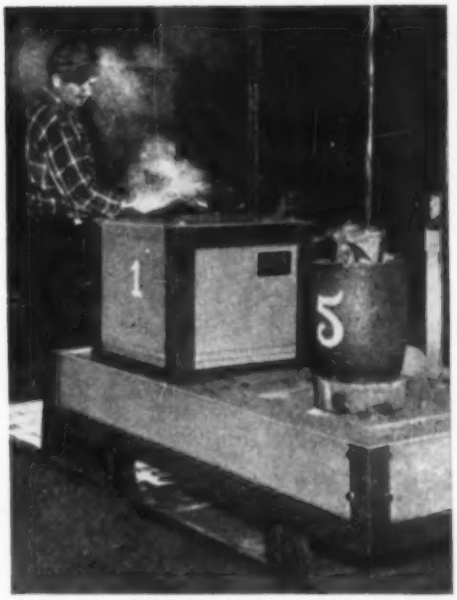
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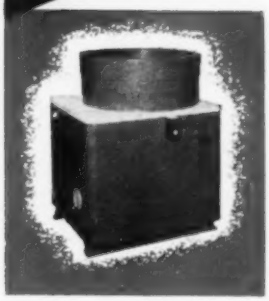
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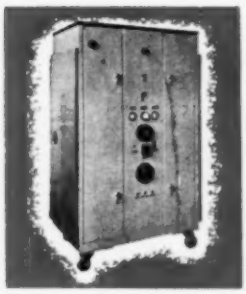
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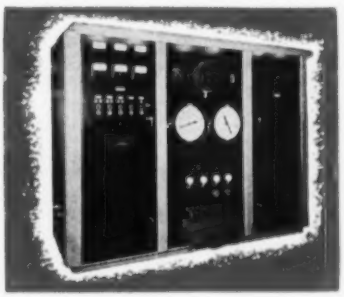
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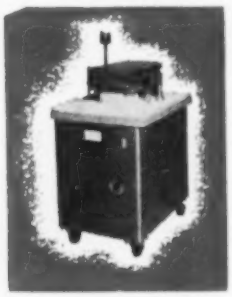
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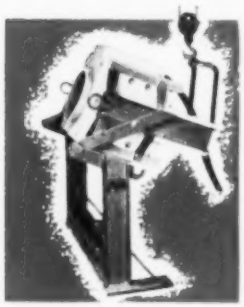
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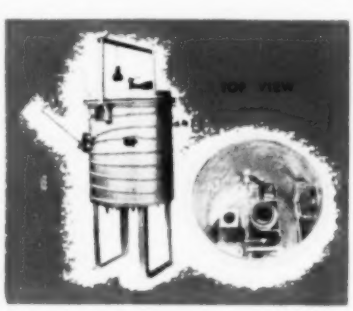
• ECCO High Frequency Motor Generator and Controls. Installations available from 20 to 1200 KW at operating frequencies from 960 to 10,000 cycles with melting capacity from 5 pounds to several tons.



• ECCO Model M40 60-Cycle Induction-type Ring Gear Expansion Heater with automatic heat control and pneumatic release. Units available ranging from 20 to 100 KW.



• ECCO Model F78 550-pound Tilting-type High Frequency Induction Melting Furnace.



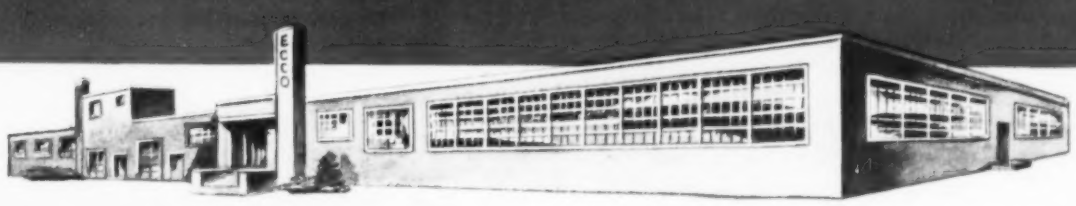
• ECCO Model F66B Coil Tilting Type High Vacuum Melting Furnace with provisions to add alloying specimens to the charge and pour the metal into a water cooled mold. Operating pressure 10—4mm. HG. temperature 2000° C+. Unit capacity available from 30 to several hundred pounds.

AVAILABLE FROM OUR STOCK

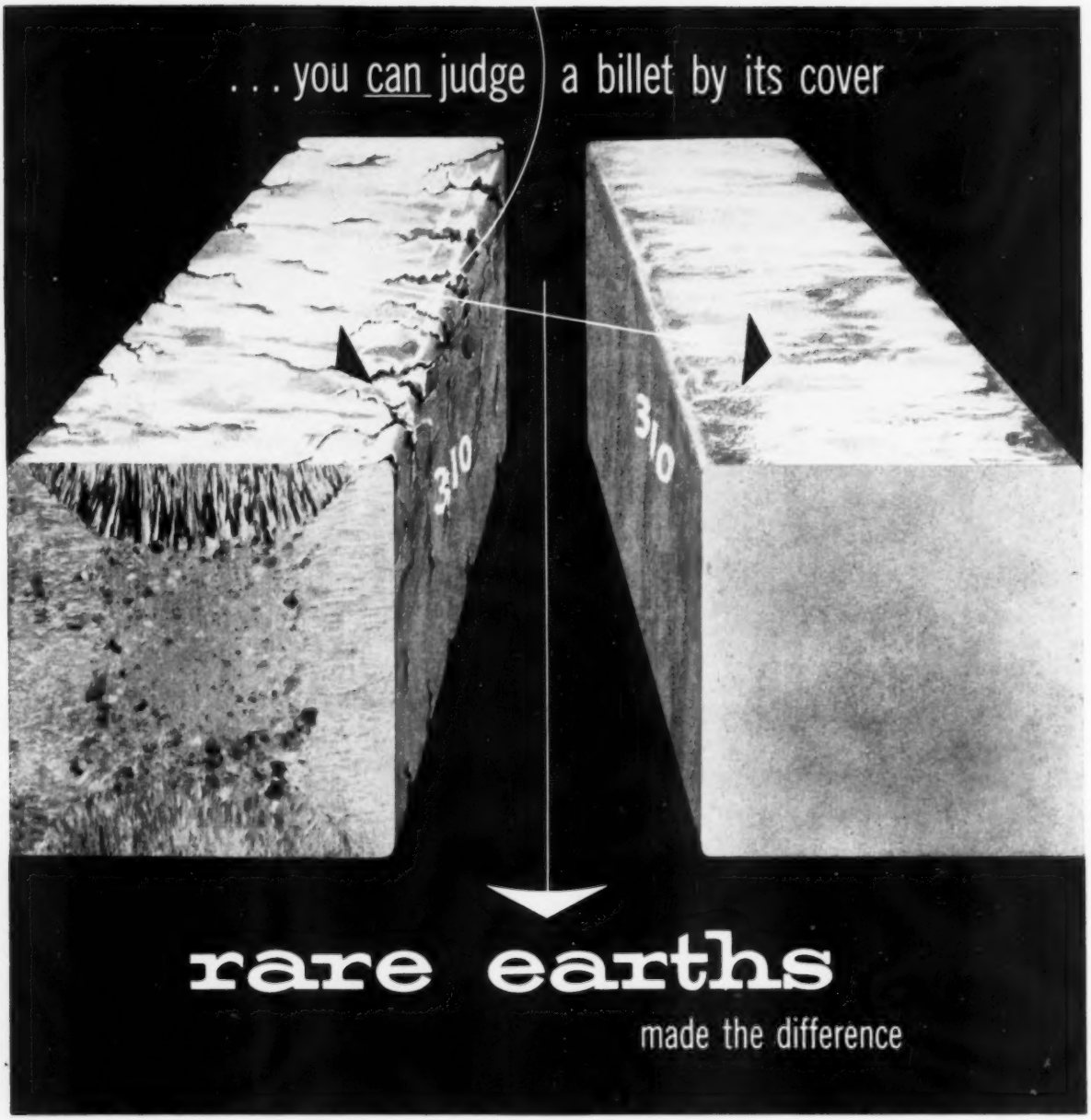
High Frequency Motor Generator Sets

100 KW,	10,000	cycle	Water Cooled
100 KW,	3,000	cycle	Water Cooled
100 KW,	3,000	cycle	Air Cooled
50 KW,	10,000	cycle	Water Cooled
50 KW,	3,000	cycle	Water Cooled
50 KW,	3,000	cycle	Air Cooled
30 KW,	10,000	cycle	Water Cooled
15 KW,	10,000	cycle	Water Cooled

IF YOU HAVE A PROBLEM concerning industrial electric heating, ECCO engineers will place their years of specialized experience at your disposal to help work out a practical, economical solution. Standard ECCO equipment in many different models is available for production and research. Where special custom designing is required, ECCO will design or build to the exact specifications of your own engineers. Either way, your inquiry will receive prompt, competent attention.



ECCO HIGH FREQUENCY CORP. **7020 Hudson Blvd., N. Bergen, N.J.**



The two billets shown were produced by a prominent manufacturer of 310 stainless steel. Before rare earth additions, the billet on the left shows a coarse columnar structure, with frequent corner cracks. Heavy cogging was necessary to permit rolling with a minimum of hot tearing; after rolling a grinding loss from the edges incurred additional production time and expense.

Consider the billet on the right, and the great improvement made by a small economical addition of **MCA RareMeT Compound**. The fine primary crystal pattern shown in the sectional view is taken from an unretouched, unmagnified photograph. This steel was rolled without intermittent heating cycles from ingot to billet, and frequently to final size, all with a minimum of hot tearing.



Write today for free Progress Report Number 1, "Rare Earths in Melting." Just off the press!

MOLYBDENUM
CORPORATION OF AMERICA
Grant Building **Pittsburgh 19, Pa.**

Offices: Pittsburgh, Cleveland, Detroit, Los Angeles, New York, San Francisco
Sales Representatives: Edgar L. Fink, Detroit; Brumley-Donaldson Co., Los Angeles, San Francisco
Subsidiary: Cleveland Tungsten, Inc., Cleveland *Plants:* Washington, Pa., York, Pa.

MCA

IONIC
HIGH POTENTIAL PAINT SPRAYING EQUIPMENT

HIGH POTENTIAL PAINT SPRAY EQUIPMENT

Minimizes Your Paint Spraying Costs!

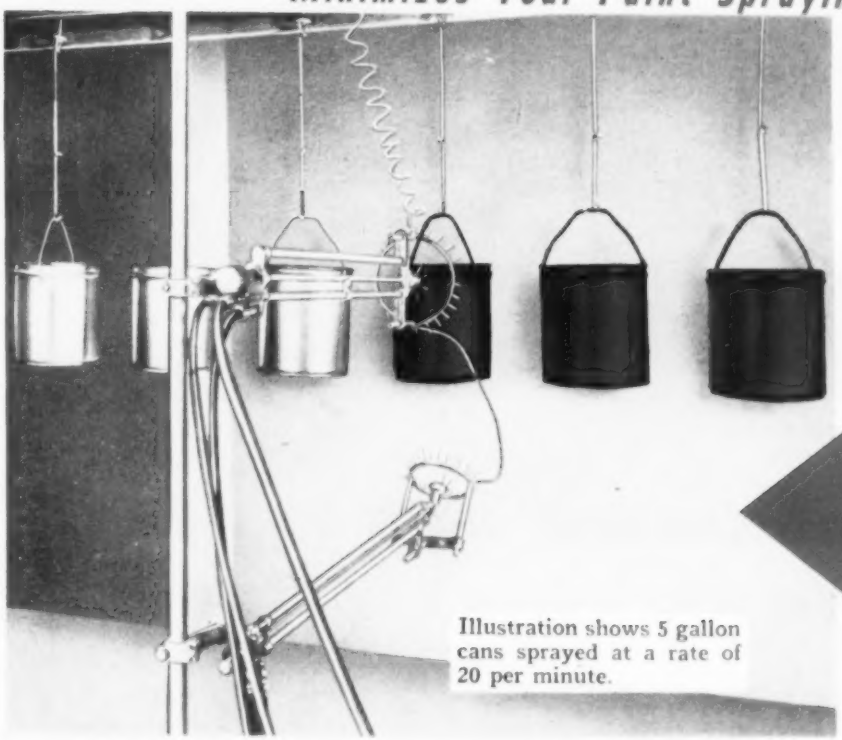


Illustration shows 5 gallon cans sprayed at a rate of 20 per minute.

Two IONIC GUNS used*

Electrically charged particles of paint are attracted to the article to be painted when using IONIC HIGH POTENTIAL PAINT SPRAYING EQUIPMENT made by SCIENTIFIC ELECTRIC.

Paint is so highly ionized with the IONIC GUN that it produces an even finish and penetrates into cavities and crevices.

SCIENTIFIC ELECTRIC'S IONIC GUN features several adapters, each for a given application all above ground. Installation is simplified with this method and most of the mystery of installing and operating such equipment is removed. Overspray is held at a minimum.

Visit our plant for a demonstration of the IONIC GUN and IONIC HIGH POTENTIAL PAINT SPRAYING EQUIPMENT and witness the use of this process on your product with your materials . . . or write now for a free brochure.

Features

- No Rentals
- No Royalties
- Speeds Up Production
- Low Capital Investment
- Minimum Paint Consumption
- Higher Product Quality

See our exhibit at Booth #2402 at the National Metal Exposition and Congress, Cleveland Public Auditorium, October 19-23.

*Patents Applied For

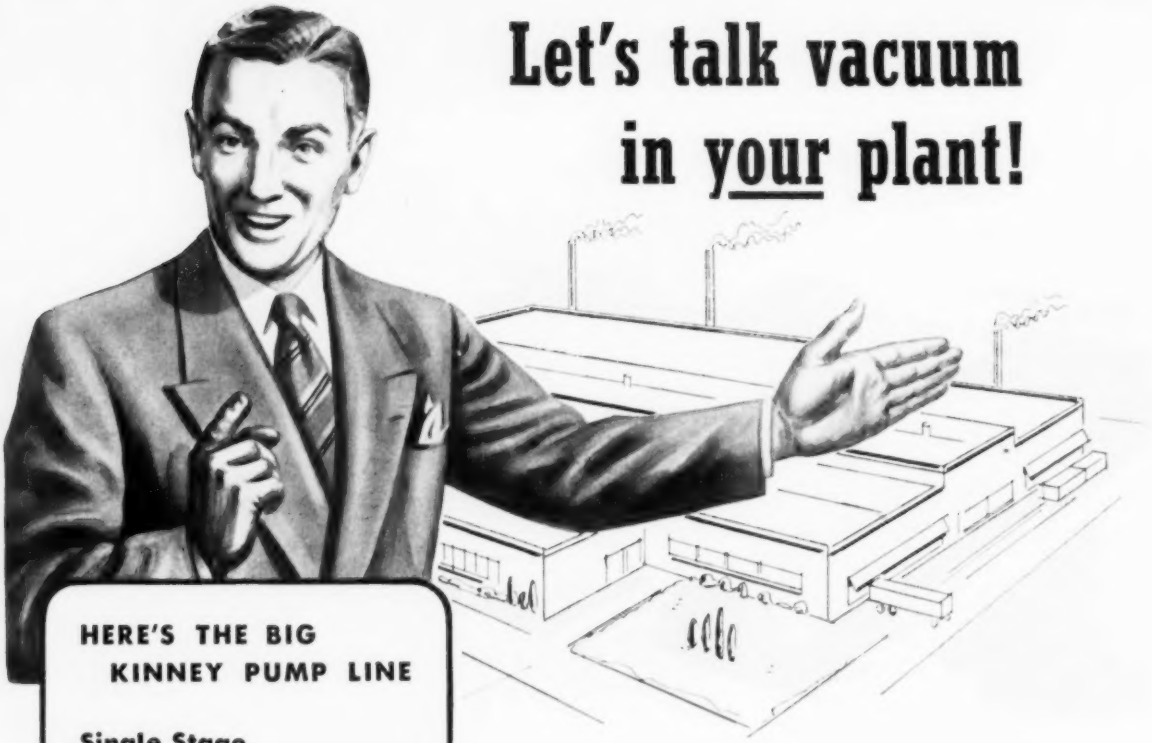
SCIENTIFIC ELECTRIC

DESIGNERS AND MANUFACTURERS OF HIGH FREQUENCY AND HIGH VOLTAGE EQUIPMENT SINCE 1921

Scientific Electric

105-119 MONROE ST. GARFIELD, N.J.

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Single Stage

Model DVH 27.20.34	1800 CFM
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Model DVD 14.14.18	486 CFM
Model DVD 14.9.18	311 CFM
Model DVM 12.8.14	218 CFM
Model DVD 8.8.10	110 CFM
Model VSD 8.8.11	52 CFM
Model VSM 7.7.8	27 CFM
Model VSM 5.5.6	13 CFM

Compound

Model CVM 8.6.10	46 CFM
Model CVM 5.5.6	15 CFM
Model CVM 3534	5 CFM
Model CVM 3153	2 CFM

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There's a qualified Kinney Vacuum Engineer in your region, ready to talk vacuum in *your* plant. Call on him. See how the BIG LINE . . . the *Kinney* line of vacuum pumps can be profitably used in exhausting lamps and tubes, freeze-drying pharmaceuticals and antibiotics, vacuum metallizing, vacuum production of titanium and other miracle metals, vacuum fumigation and impregnation — and in the countless other ways vacuum serves industry today. Kinney Manufacturing Co. — manufacturers of vacuum and liquid pumps. Boston, New York, Chicago, Detroit, Cleveland, Atlanta, Pittsburgh, Philadelphia, Los Angeles, Charleston (W. Va.), Houston, New Orleans, San Francisco, Seattle, and foreign countries.

2 IMPORTANT ANNOUNCEMENTS



GAS BALLAST

when applicable — All sizes of Kinney Vacuum Pumps can be equipped with gas ballast to assist in your water-oil contamination problems.

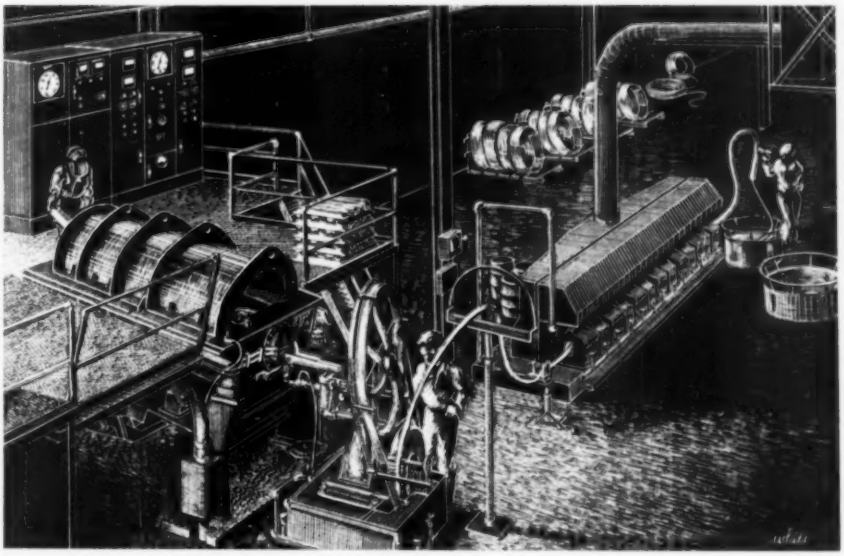


NEW MECHANICAL BOOSTER PUMP

Model MB 1200. "Clean" vacuum . . . extremely high pumping speeds (1000 CFM at 10 microns) . . . low power (15 HP) . . . particularly suited for metallurgical processes where large volumes of gases are liberated.

FOR DETAILS WRITE **KINNEY MANUFACTURING CO., 3584 WASHINGTON ST., BOSTON 30, MASS.**

From Molten Aluminum to 3/8" Diameter Rod in 1½ Minutes!



Rome Cable Corporation

uses AJAX INDUCTION FURNACES for

MELTING ALUMINUM FOR CONTINUOUS CASTING AND ROLLING OF HIGH CONDUCTIVITY ROD

The picture above, a drawing made at the Rome Cable Corporation, Rome, N.Y., shows one of the most modern installations in the country for the continuous casting and rolling of aluminum rod directly from molten metal. From left to right are shown the electric controls of the adjacent 450 kW. AJAX low frequency induction combined melting and holding furnace which is pouring molten metal into the Properzi continuous casting machine in the foreground, and the rolling mill from which the coiled rod is emerging.

This installation casts at the rate of about one ton per hour. The furnace feeds a continuous stream of molten aluminum at automatically controlled temperature into a rim cavity on the slowly revolving wheel of the Properzi machine. Metal loss from pig to rod averages less than 1 pct. Mechanical properties and electrical conductivity are excellent; the material is sound and fine grained. The men work under cooler, cleaner conditions because the only heat generated is within the melt itself. Due to melting conditions inherent in AJAX furnaces, the operation is continuous and no fluxing is required.

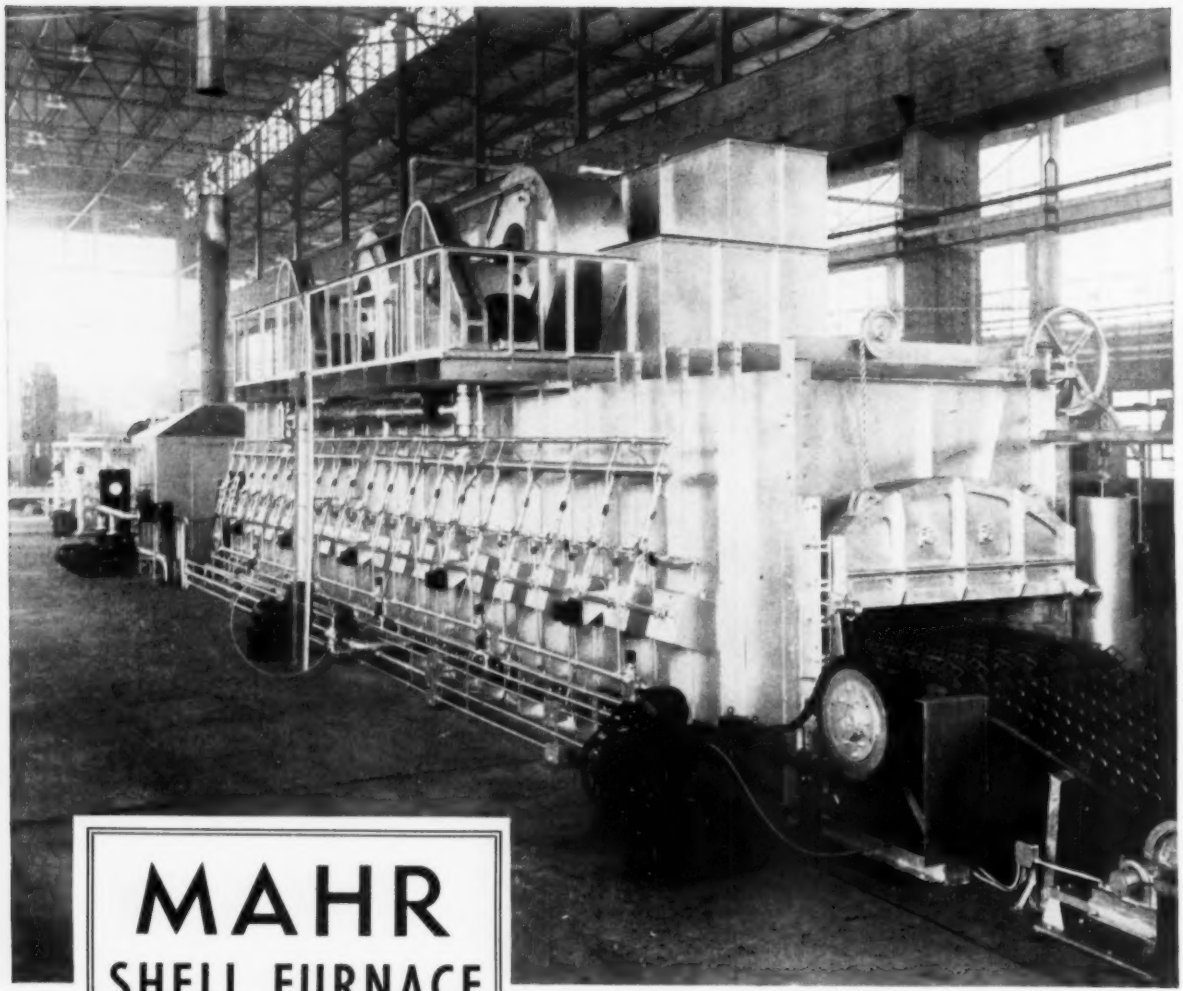
VISIT THE AJAX BOOTH, NO. 221, AT THE METAL SHOW

AJAX TAMA-WYATT

AJAX ENGINEERING CORP., TRENTON 7, N. J.

INDUCTION MELTING FURNACE

AJAX ELECTRO METALLURGICAL CORP., and Associated Companies
AJAX ELECTROTHERMIC CORP., Ajax Northrup High Frequency Induction Furnaces
AJAX ELECTRIC CO., INC., The Ajax Hultgren Electric Salt Bath Furnace
AJAX ELECTRIC FURNACE CORP., Ajax Wyatt Induction Furnaces for Melting



Mahr Chain Conveyor, Recirculating, Air Draw Shell Furnace

MAHR
SHELL FURNACE

MAHR'S "Roller Rail" hearth system makes it practical to mass produce 75mm to 155mm shells... 300 per hour with perfect uniformity... without rejects. Fully automatic from start to finish, the MAHR Shell Furnace hardens, quenches and draws shells in one continuous operation. A MAHR furnace, fired by either gas or oil (or both) assures uniform distribution of heat with lower operating costs.

Tell us (1) the size shells you make, (2) your production requirements and (3) your available fuel and we will send you complete information and specifications for your individual needs . . . without obligation.

OTHER MAHR FURNACES

- Car Type
- Pusher
- Rotary
- Batch
- Continuous
- Pit
- Gas or Oil Fired

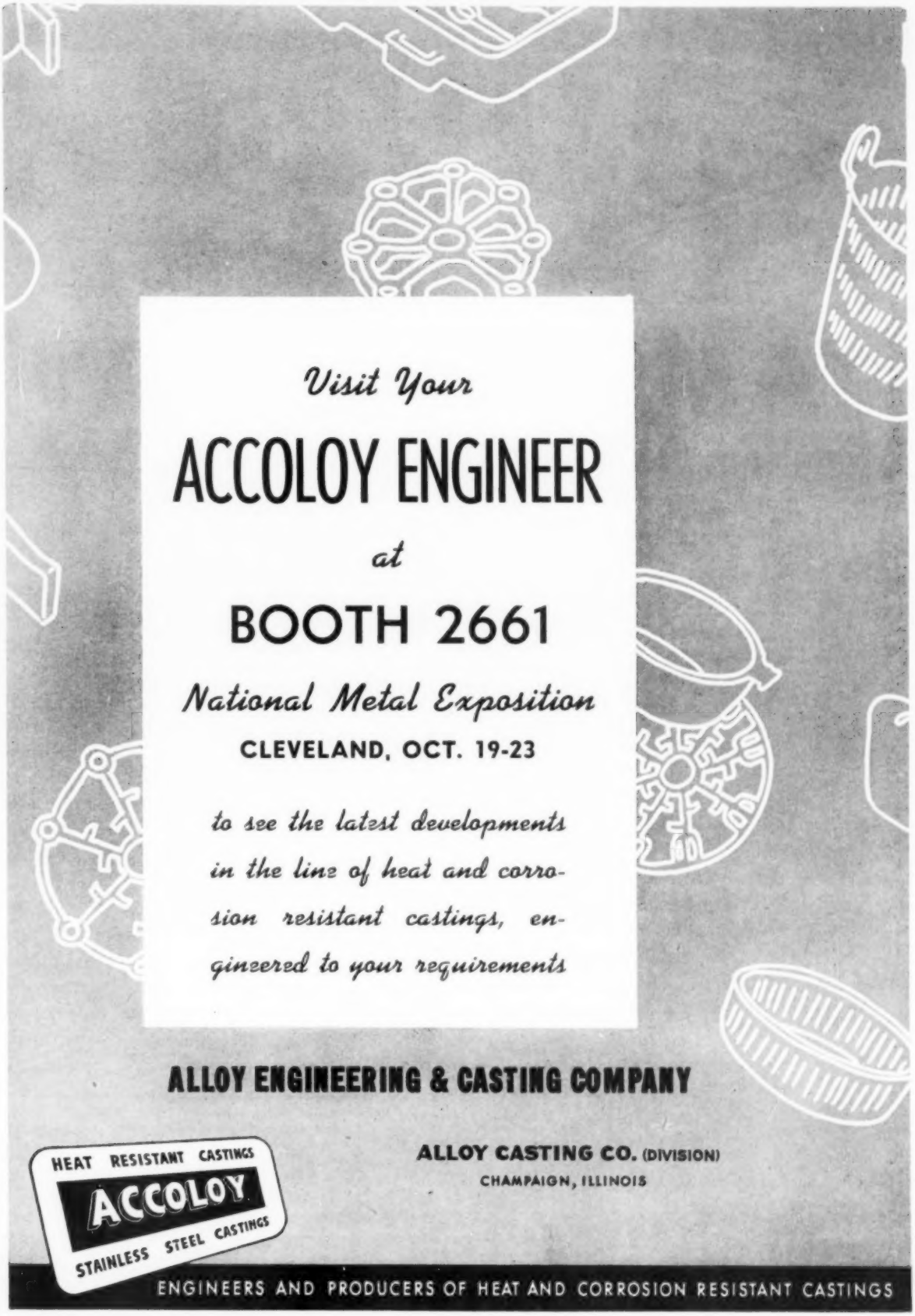
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for Defense and Civilian Production

MAHR'S RECIRCULATING, AIR DRAW, STRESS RELIEF FURNACES are designed and engineered to insure a rapid, uniform heat, exactingly controlled for your particular requirements.

The advanced principles of heat treatment and furnace design developed during 30 years of research are all included in MAHR Furnaces to provide a ruggedly constructed unit that will operate efficiently for years.

WRITE US for bulletins and detailed information on any kind of furnace installation. MAHR'S engineers and consultants will gladly advise and specify the proper equipment for you.

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AMPCO®

Producers of..."The Metal Without an Equal"

AMPCO* METAL

...the special alloys that make good where other metals fail

HERE are some of the properties of Ampco Metal that help you keep production up, costs down:

- **Unusual resistance to wear from abrasion, erosion, and cavitation pitting.**
- **Excellent resistance to corrosion in certain media.**
- **High tensile and compressive strength.**
- **High physicals at extreme temperatures.**
- **High strength-to-weight ratios.**
- **High impact and fatigue values.**

Because it combines all of these qualities, Ampco Metal is often called The Metal Without an Equal.

No matter what you do — whether you run a steel mill, refine oil, make stampings, generate power, work in the chemical or process industries, or any of hundreds of other jobs, you can make Ampco Metal work for you. It saves operating headaches and production grief, because it often makes good where other metals fail.

These versatile special alloys fight wear, corrosion, impact, fatigue; give long life and dependable performance under the severest conditions. That's why they are widely used in such tough assignments as slippers and screw-down nuts for blooming mill service, fractionating towers, aircraft parts, dies, valves, bushings, and other punishing jobs.

Chances are Ampco Metal can help you, too. It's available in sand and centrifugal castings, sheets, plates, bars, tubes, extrusions, welding wire and electrodes. Consult your nearby Ampco field engineer or write us for full information.

*Reg. U. S. Pat. Off.

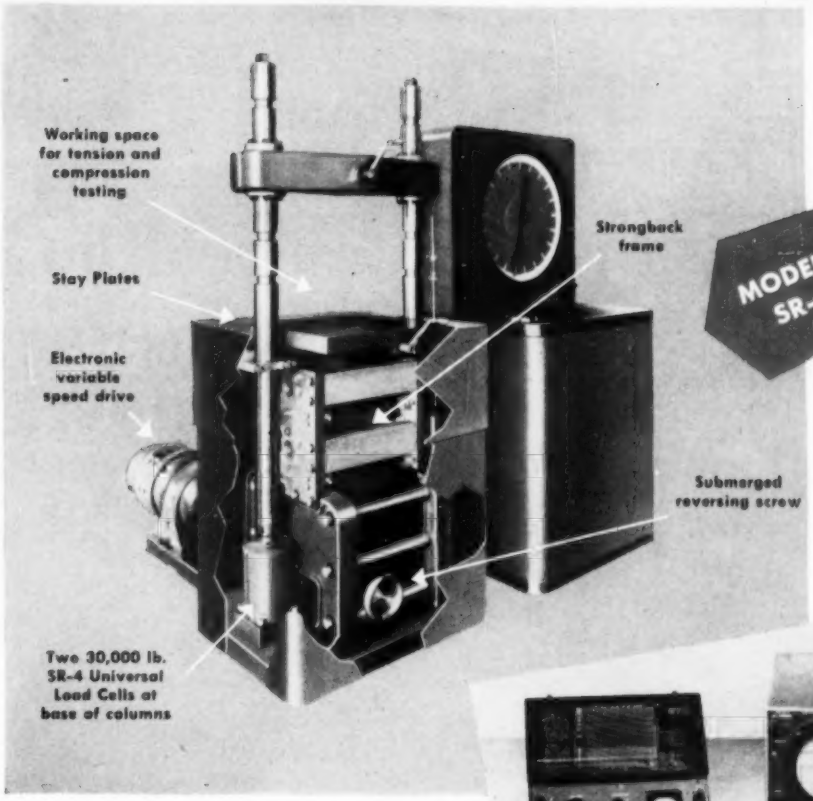
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West Coast Plant, Burbank, California

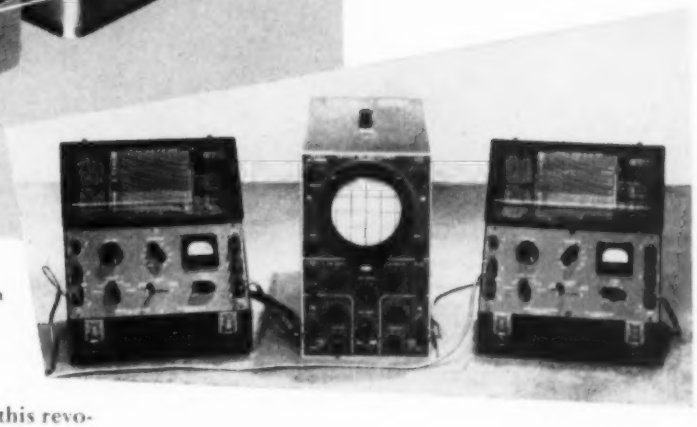
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NOW! A Machine Fast Enough for SHOCK Tests on Structures



MODEL FGT BALDWIN-EMERY SR-4 TESTING MACHINE



Oscilloscope X-Y diagram system records stress-strain curves in shock testing

The extraordinary high speed of response of this revolutionary new Baldwin-Emery universal testing machine, paired with an oscilloscopic X-Y diagram, enables it to measure and record shock tests on complete structures. Its SR-4 load cells and SR-4 type extensometer make it capable of responding to the rates required by shock conditions.

The load cells and extensometer feed signals to the oscilloscope through pre-amplifier circuits. An instantaneous stress-strain curve and its two axes then appear on the oscilloscope screen. It is possible to have this screen photographed continually to record changes in the shape of the stress-strain curve as the structure itself changes.

Its unique aptness for such shock tests is one of the reasons why the FGT SR-4 Testing Machine is being recognized as *the greatest advance in materials testing equipment in twenty years.*

Full details on this latest contribution of Testing Headquarters are in Bulletin 4202. For your copy, write to Dept. 2224, Baldwin-Lima-Hamilton Corporation, Philadelphia 42, Pa.

BALDWIN BLH LIMA-HAMILTON

TESTING HEADQUARTERS

BALDWIN-LIMA-HAMILTON

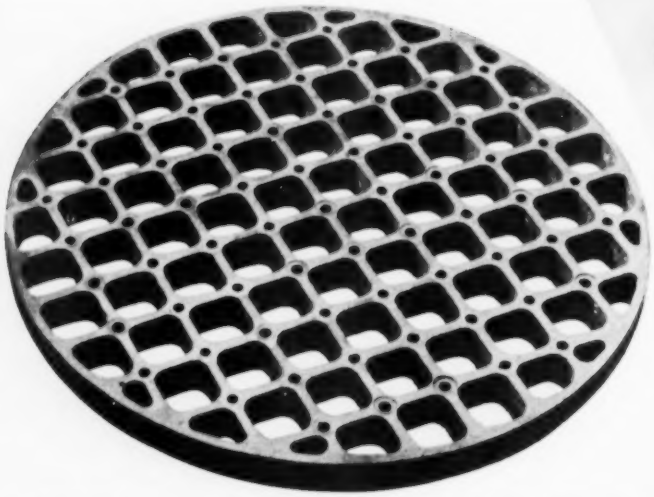
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WAUKESHA's 321

(titanium stabilized)

STAINLESS STEEL CASTINGS



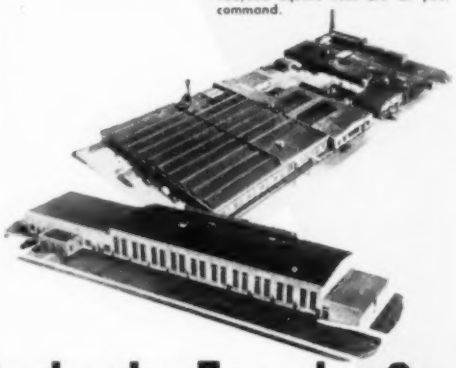


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--TO SOLVE YOUR MACHINING AND WELDING PROBLEMS



40 years of leadership in producing unusually difficult castings have made WAUKESHA one of the large jobbing foundries in the country. Four foundries with a total of over 130,000 square feet are at your command.



You can count—just on the fingers of one hand—the foundries who can successfully cast No. 321 stainless steel with titanium. But WAUKESHA metallurgical engineers have found the secret . . . WAUKESHA castings of 321 are completely unaffected by welding processes; their high corrosion resistance is unimpaired.

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EQUIPPED TO SERVE YOU FROM BLUEPRINT *through the finished casting*

Waukesha Foundry Co.

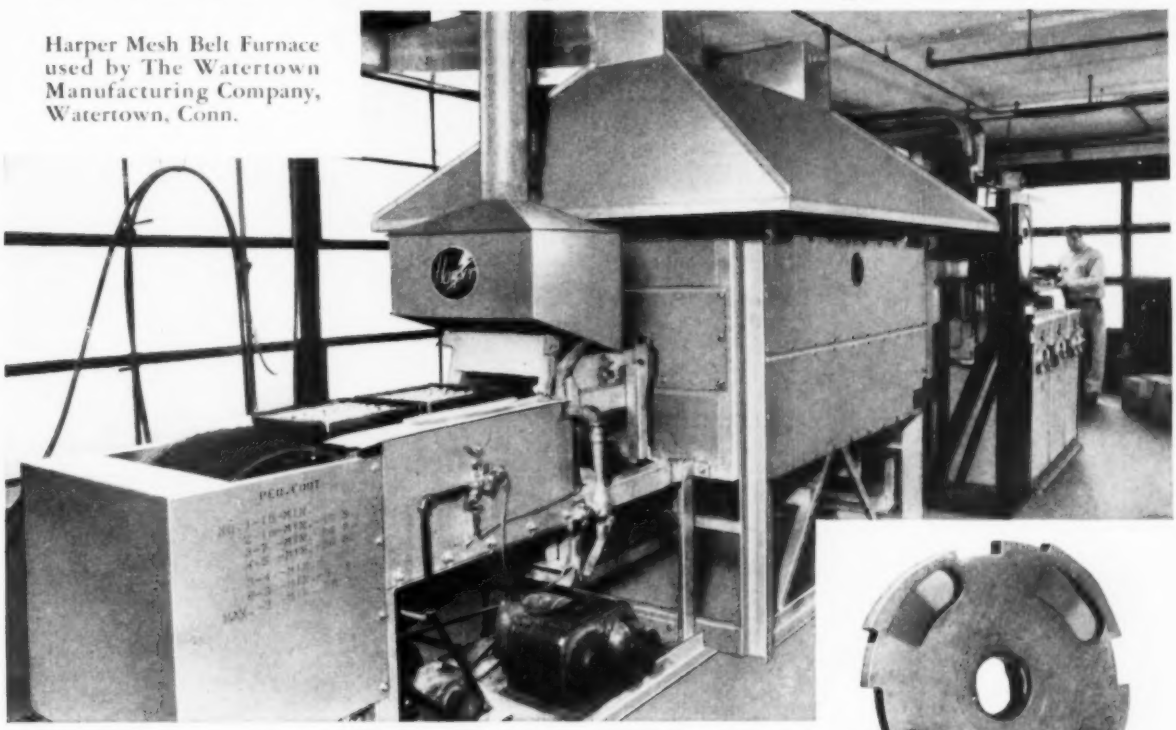
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WAUKESHA, WISCONSIN

SAVE MACHINING COSTS

Consider Sintering for Complex Parts

Harper Mesh Belt Furnace used by The Watertown Manufacturing Company, Watertown, Conn.



Insert shows a complex part, which is one of the many unusual parts being sintered.

THE WATERTOWN MANUFACTURING COMPANY has helped many customers reduce costs by adapting their part to metal powdered process.

Other fabricators considering sintering furnaces should check these features found in Harper Furnaces:

- More Uniform Product Resulting From Use Of Easily Controlled, Unvarying Electric Heat.
- Closer Control of Product Dimensions Through More Positive Control Of Furnace Preheat Temperature.
- Longer Belt Life Through Improved Belt Take-Up Design.
- Substantial Cost Savings . . . Through Less Down Time and Efficient Use Of Electricity.

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HARPER ENGINEERS WILL WELCOME YOUR HEAT TREATING PROBLEMS

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BOOTH #647
1953 Metal Show
Cleveland
OCT. 19-23

HARPER ELECTRIC FURNACE CORPORATION
DEPT. 7, 39 RIVER STREET, BUFFALO 2, NEW YORK

NEW BUEHLER CATALOG



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October 19-23, 1953

200 pages — a comprehensive catalogue of Buehler equipment for the metallurgical laboratory. Includes sections on Cutters, Grinders, Specimen Mount Presses, Polishers, Metallographs, Microscopes, Cameras, Testing Machines, Spectrographs, Furnaces and other equipment for the metallurgical laboratory.

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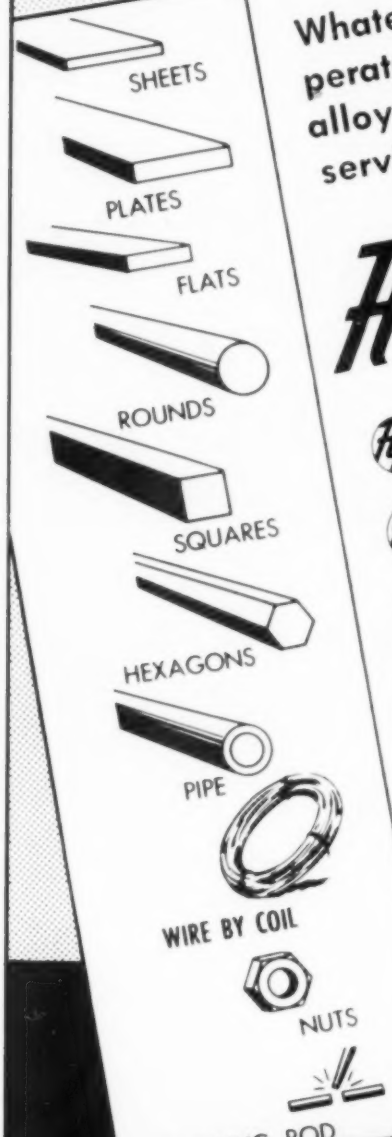




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Whatever your high temperature requirements, one of these alloys will give you maximum service per dollar invested.

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- RA TYPE 430 . . . . . 17 Cr
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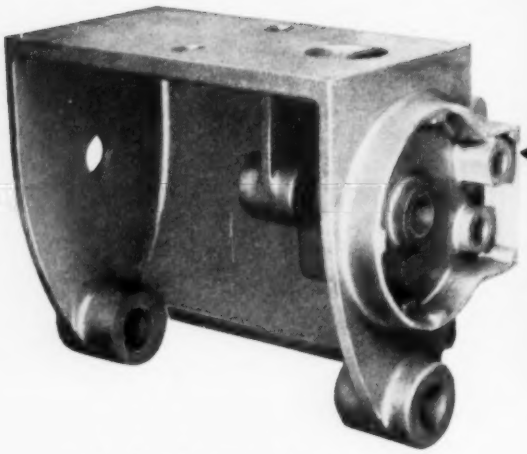
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Heat and Corrosion Resistant Alloy Specialists

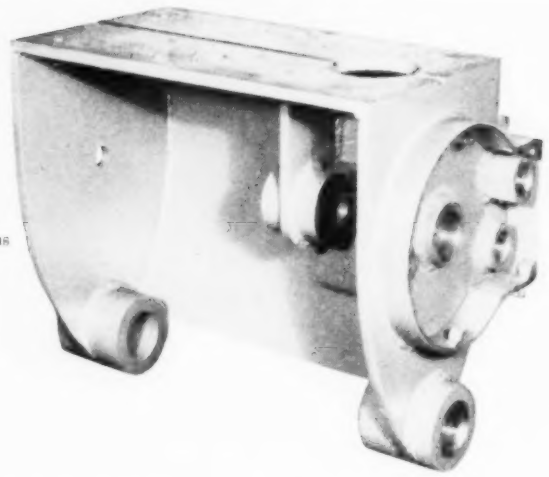
4815 BELLEVUE AVENUE. DETROIT 7. MICHIGAN • TEL. WALNUT 1-4462



Gearbox for power-driven saw, as cast in Gray Iron.

45% SAVED...
on original cost of part

41% SAVED...
on machine and labor expense



Fabricated gearbox, which was replaced by the cast design.

By redesigning in Gray Iron, it is often possible to effect substantial cost savings. Here is a striking example:

> The manufacturer of a large power-driven metal saw found that the cost of a fabricated gearbox (right above) was out of line from a competitive standpoint. Designs for a suitable Gray Iron casting were requested and approved. Result:—the Gray Iron casting is effecting a saving of 45% on original cost of the part, plus a saving of 41% on machine and labor expense.

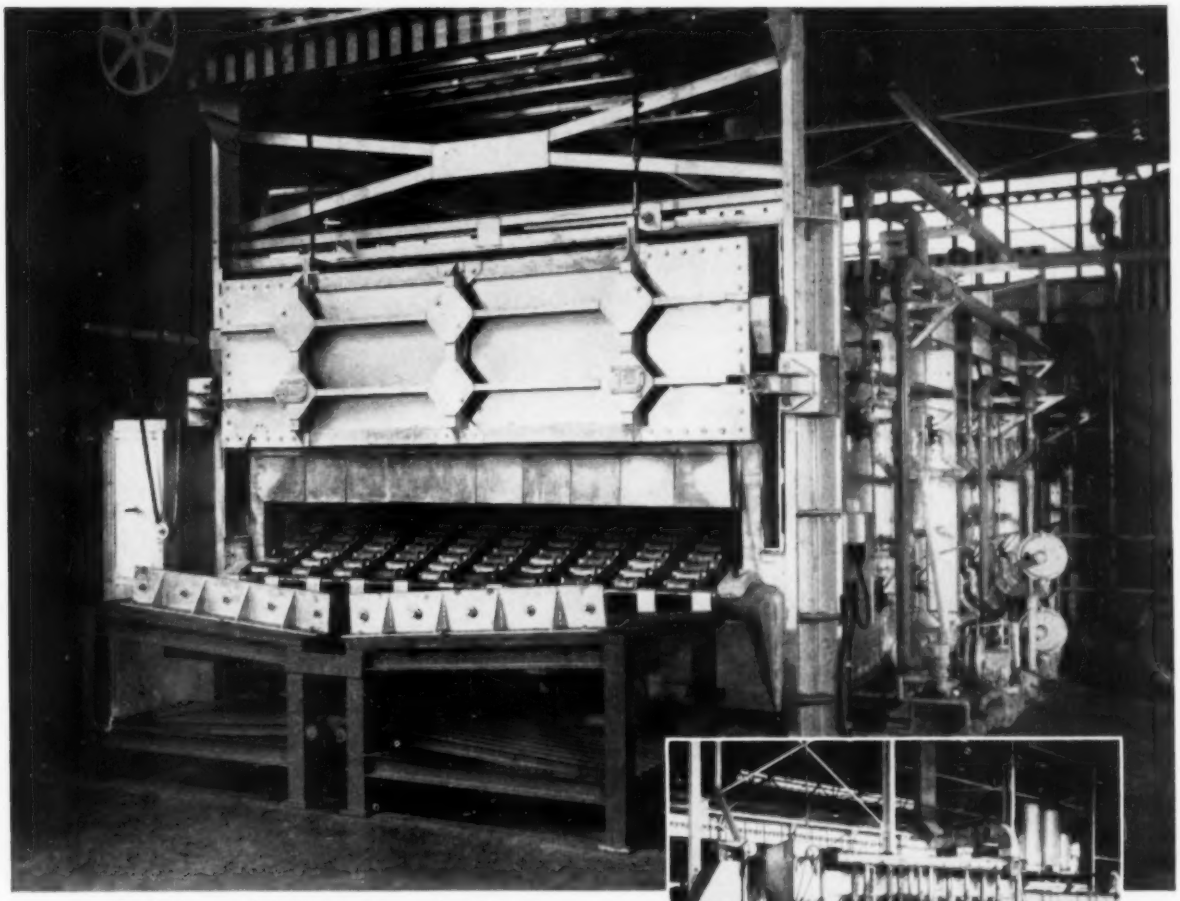
Doesn't this suggest that it's time to analyze *your* costs on certain fabricated parts—with a view to producing them better and more economically in Gray Iron? Write for technical information on the many advantages of the Gray Iron casting process.

GRAY IRON
Characteristics Include:

- Castability
- Rigidity
- Low Notch Sensitivity
- Wear Resistance
- Heat Resistance
- Corrosion Resistance
- Durability
- Vibration Absorption
- Machinability
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Make it Better with Gray Iron • **Second largest industry in the Metal-working field**

GRAY IRON FOUNDERS' SOCIETY, INC.
NATIONAL CITY-E. 6th BLDG., CLEVELAND 14, OHIO



Gas-fired copper billet heating furnace, where billets are heated prior to processing.

AT

REVERE COPPER AND BRASS INCORPORATED

LOS ANGELES, CALIFORNIA

Dempsey Gas-fired annealing furnace in the Los Angeles plant of Revere Copper and Brass Incorporated.

GAS is a production line tool

IN THE MANUFACTURE OF RODS AND TUBES for industrial, maritime, and plumbing applications, GAS provides the type of precision heat treating needed at Revere Copper and Brass Incorporated.

For instance, Revere eliminates the cold-draw cycle by using a Gas-fired annealing furnace to bring the billets right up to extrusion temperature. Bright annealing too is done by heat treating the copper tubing in controlled atmospheres in a large, Gas-fired furnace.

These methods of heat treating with GAS at Revere have the added advantages of automatic control, which makes it possible to maintain precise temperatures at all times with complete flexibility of operation.

Throughout *all* industry, GAS is a production-line fuel. Why not call your Gas Equipment Dealer or Gas Company Representative right away, and find out where GAS may help you improve the efficiency of your operation.

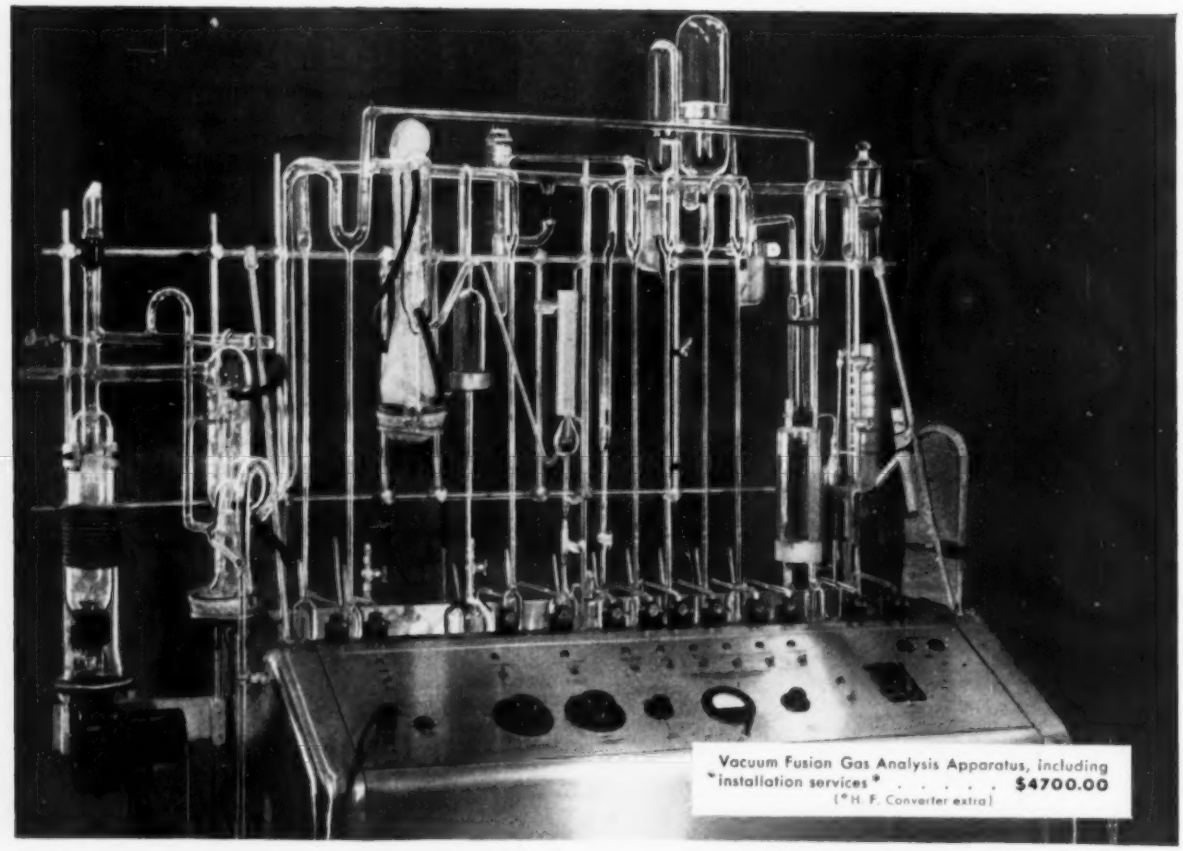
MORE AND MORE ... THE TREND IS TO GAS FOR INDUSTRIAL PROCESSING

AMERICAN GAS ASSOCIATION

420 LEXINGTON AVENUE, NEW YORK 17, NEW YORK

Vacuum Fusion Gas Analyzer

with complete installation and instruction



Vacuum Fusion Gas Analysis Apparatus, including installation services* $4700.00
(*H. F. Converter extra)

A packaged unit to determine the content of oxygen, nitrogen and hydrogen in metals

A wide variety of metals and alloys can be analyzed to determine the amount of oxygen, nitrogen and hydrogen contained either as combined or dissolved gas, in the range from one per cent to approximately 10^{-4} per cent by weight.

The oxygen and hydrogen content of titanium is reported within the same range of accuracy as for other metals.

The apparatus incorporates the best features and techniques reported in the literature or known to our laboratory and has been employed for some time in connection with our own metallurgical research activities.

Operating procedure is relatively simple and can be readily mastered. Installation, final testing and instruction of your operator is performed by one of our trained analysts.

Write for details of Type 09-1240 Vacuum Fusion Gas Analysis Apparatus.

ANALYTICAL SERVICE

Write for information about NRC Gas Analysis Service if your requirements do not justify the purchase of an instrument.

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CHEMISTRY, METALLURGY
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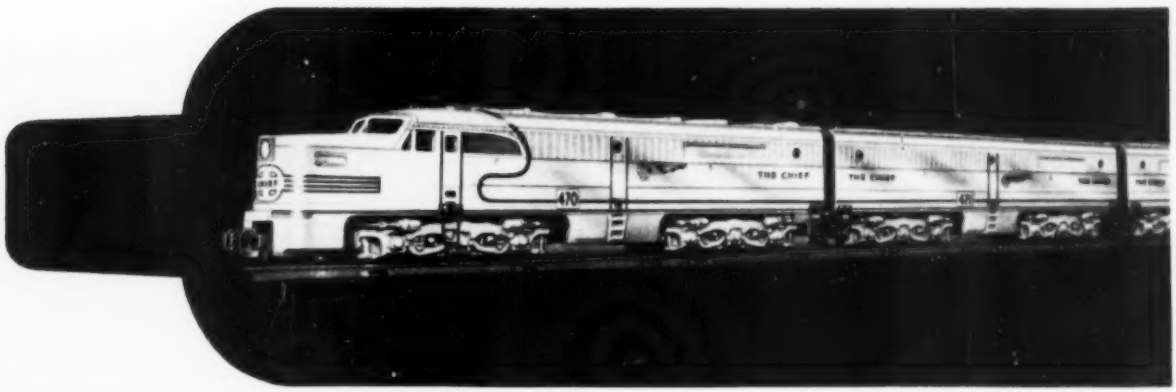
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NATIONAL METAL EXPOSITION

How Armour ammonia cuts costs in sintering powdered metal parts



A. C. Gilbert uses a protective atmosphere of dissociated ammonia to sinter 102 parts for this American Flyer model train

Protective atmospheres of dissociated ammonia have proved efficient and economical for sintering powdered metals, as well as bright annealing, bright heat treating and other metal treating applications. Dissociated ammonia provides an easily controlled atmosphere at much lower cost than hydrogen. One cylinder of ammonia yields the equivalent of 34 cylinders of hydrogen—and is much less costly!

A. C. Gilbert has been using dissociated ammonia since 1951 to provide a protective atmosphere for sintering powdered metal parts of all kinds. They have had such success—in efficiency and economy—with powdered metallurgy and with dissociated ammonia that their equipment is running 24 hours a day, 6 days a week.

Gilbert is one of many satisfied customers using Armour ammonia. In many cases, Armour men have given help and advice on installations. That's just part of Armour's service to our ammonia customers. Since 1947, Armour has sponsored a fellowship at Massachusetts Institute of Technology for the study of metal treating processes using ammonia. The men of Armour's Technical Service Department are equipped to handle and answer any problem arising with ammonia installations for metal treating.

The booklets offered at right will show you how to put this know-how to work for you. Write today for your free copies. If your problems are unusual or pressing, write giving full details of your requirements.

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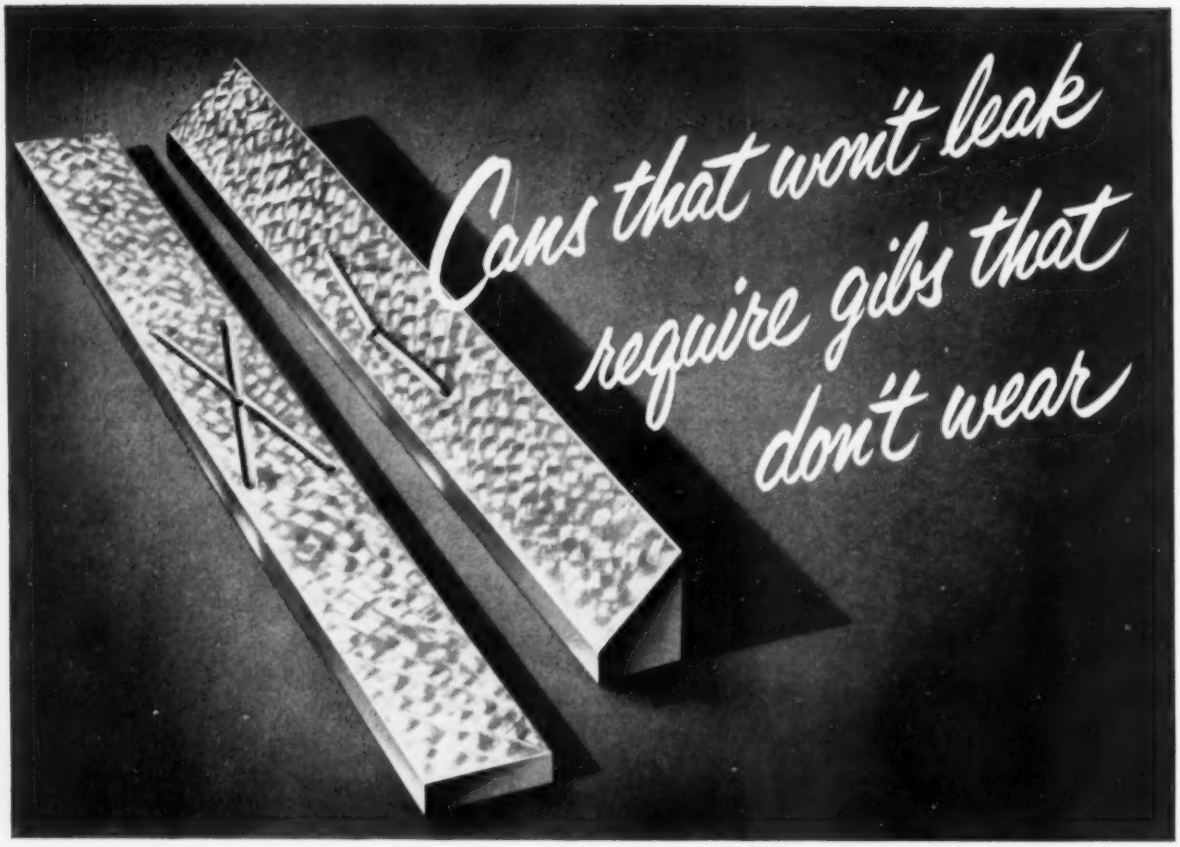
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* Data supplied by Crown Can Co. (Div. C. C. & S. Co.), Phila., Pa.

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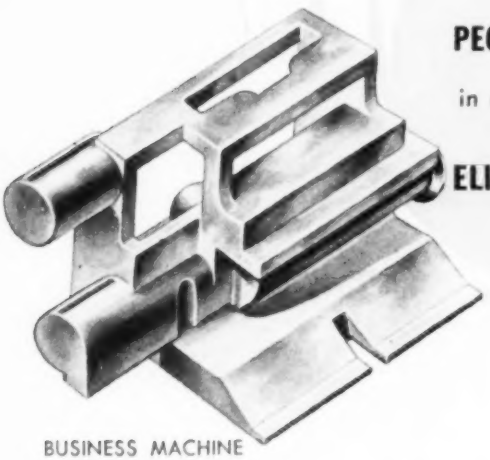
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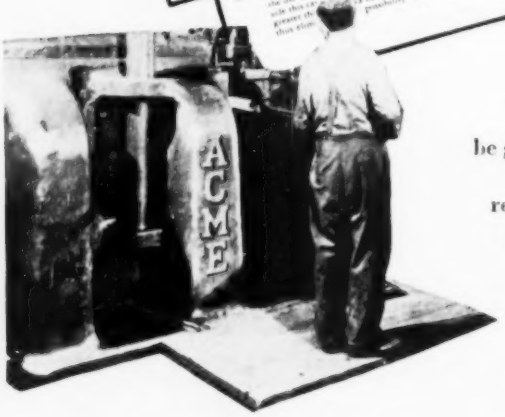
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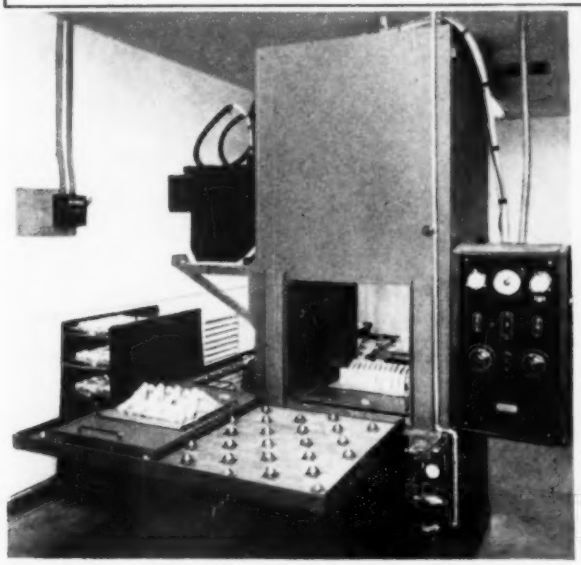
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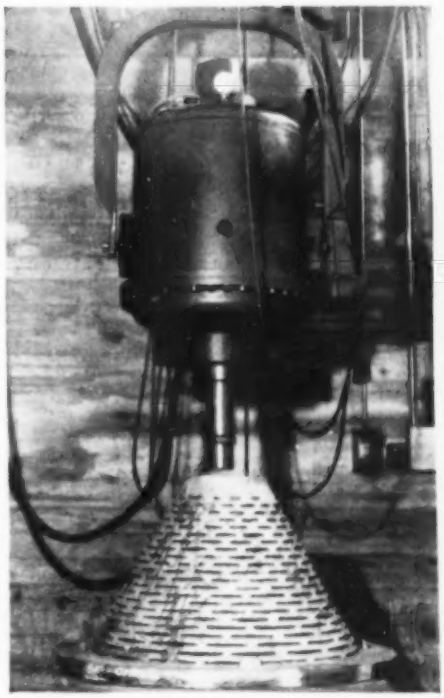
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TIN NEWS, issued monthly, covers noteworthy current developments in the production, marketing and use of tin. Write for a free copy.



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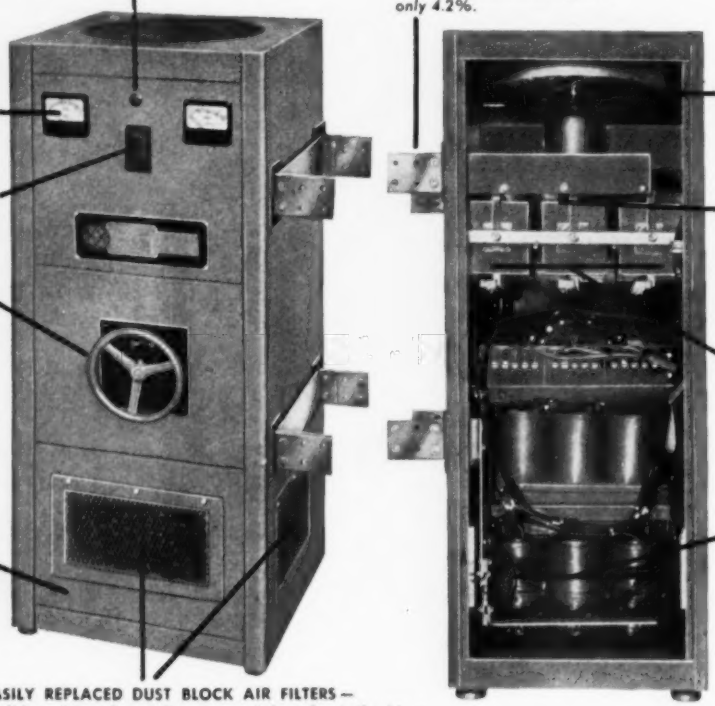
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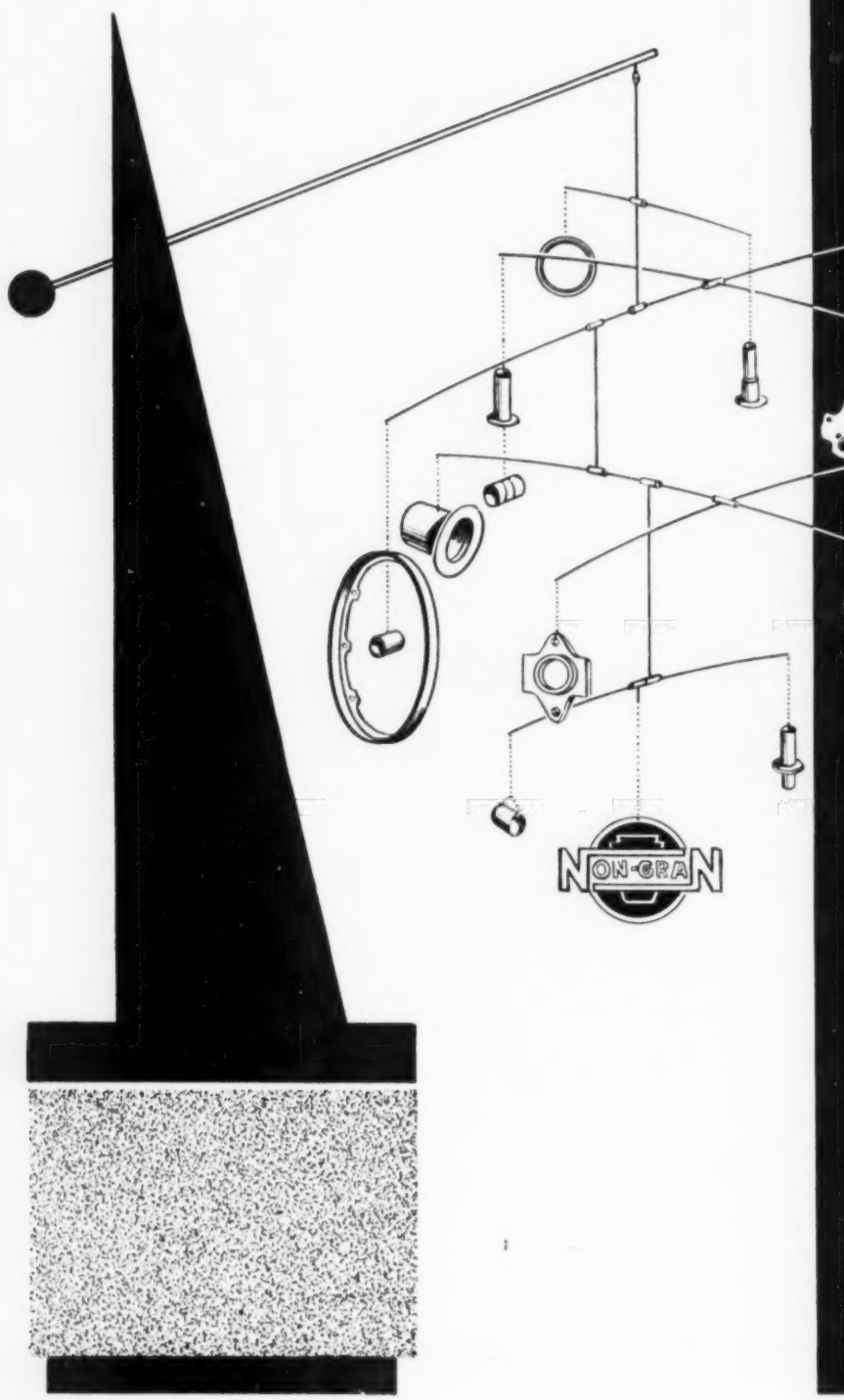
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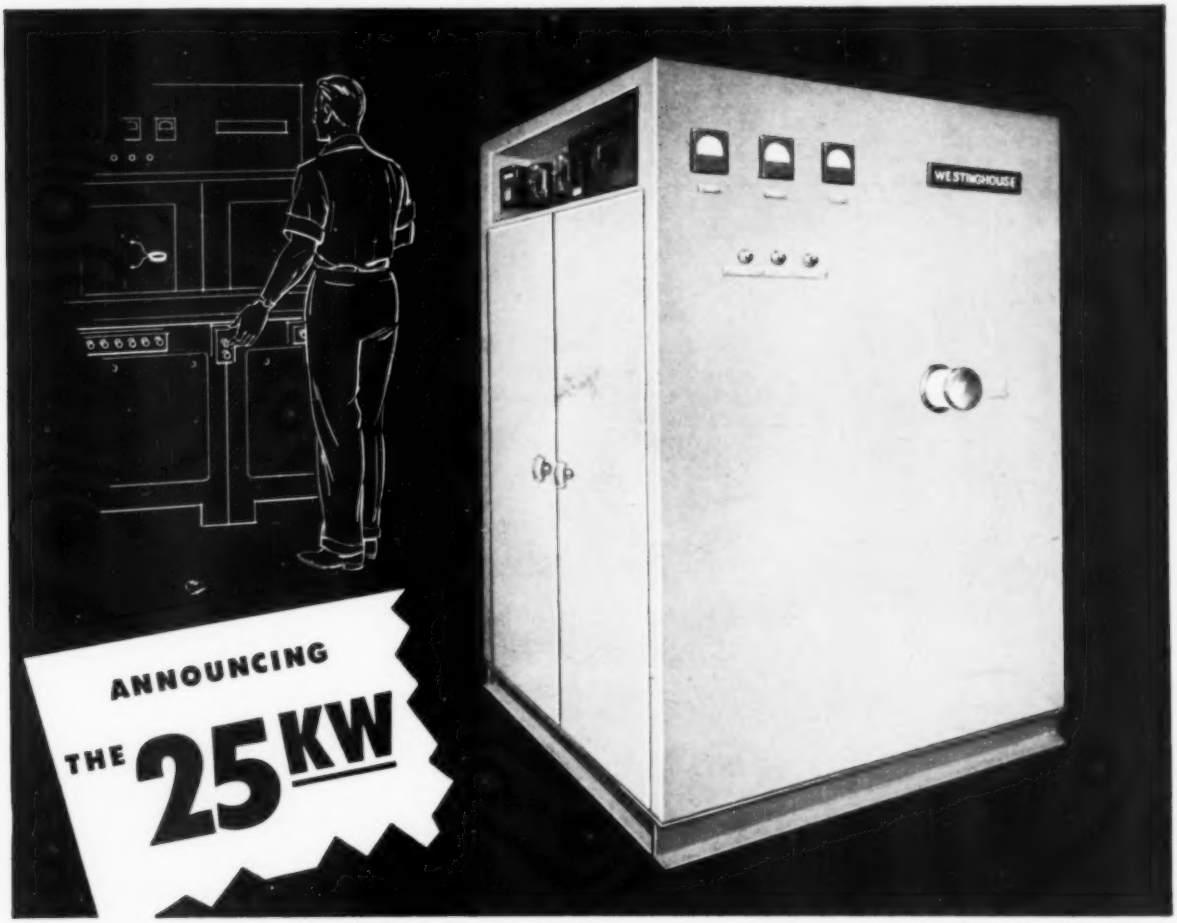
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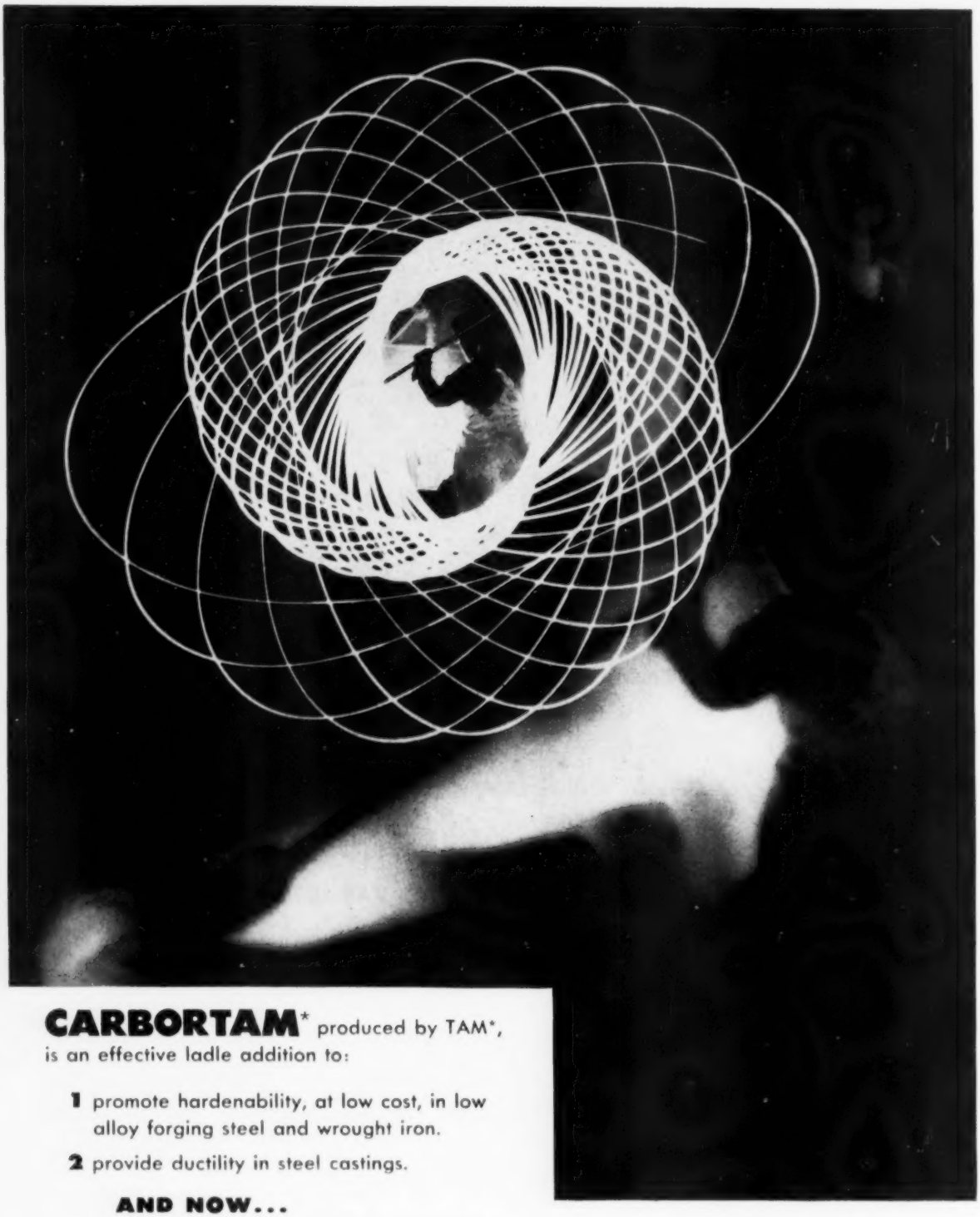
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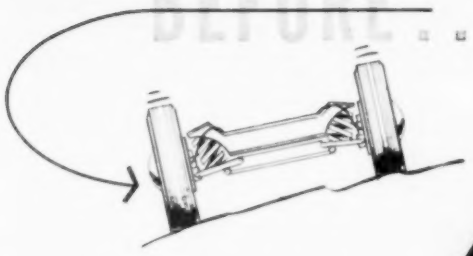
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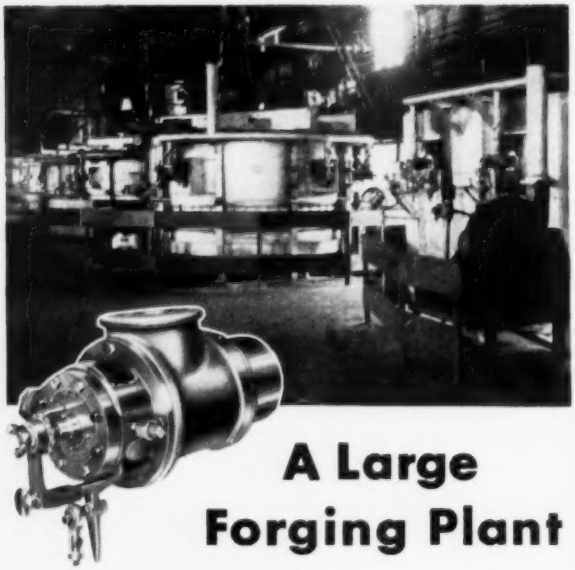
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on the RCA Electron Microscope (EMT-3) and RCA's training assistance program, write Scientific Instruments, Dept. 72V, Radio Corporation of America, Camden, N. J.

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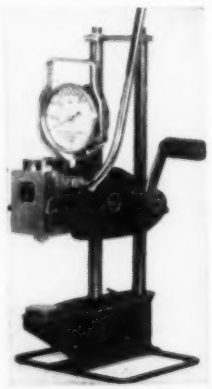
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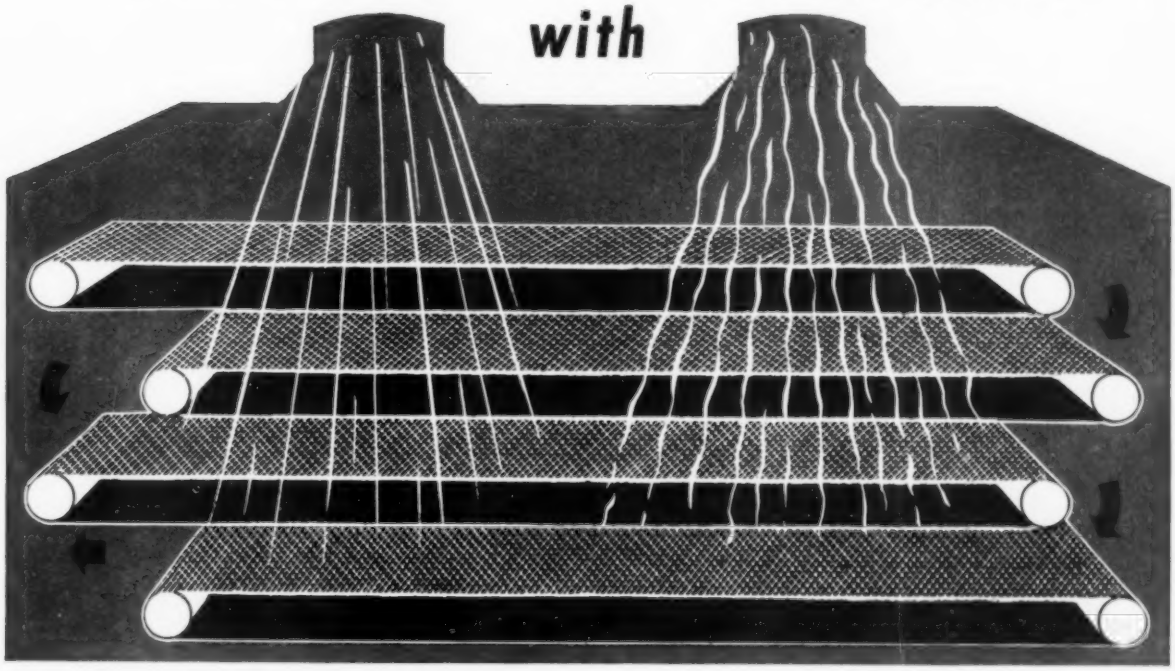
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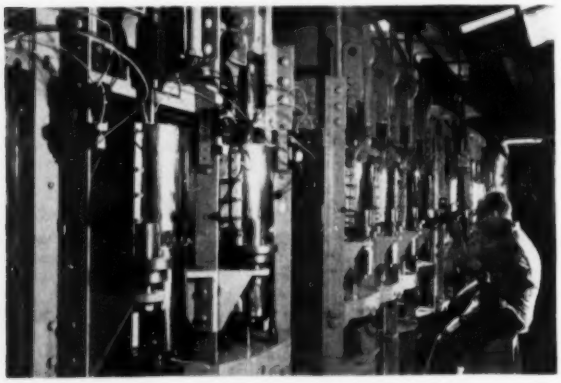
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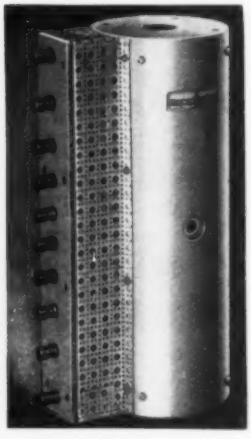




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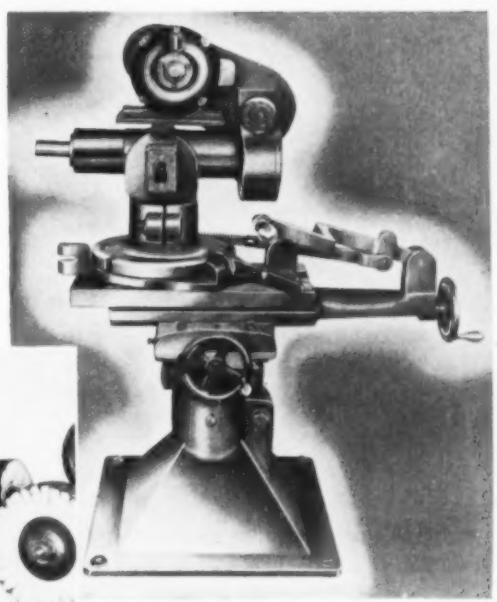
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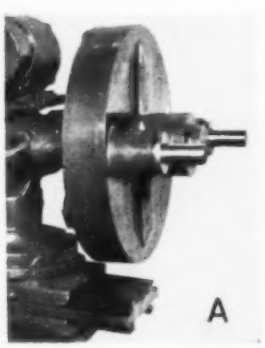
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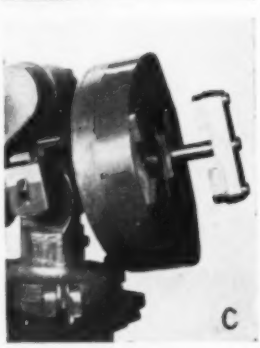
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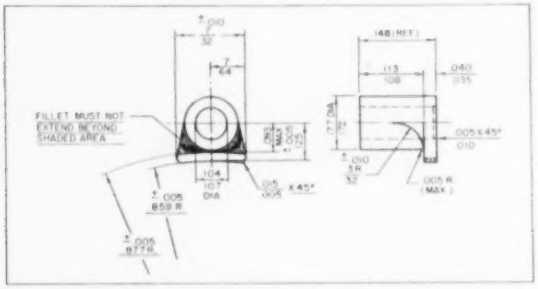
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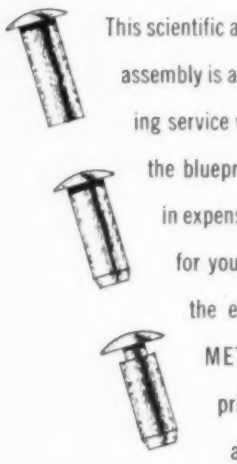
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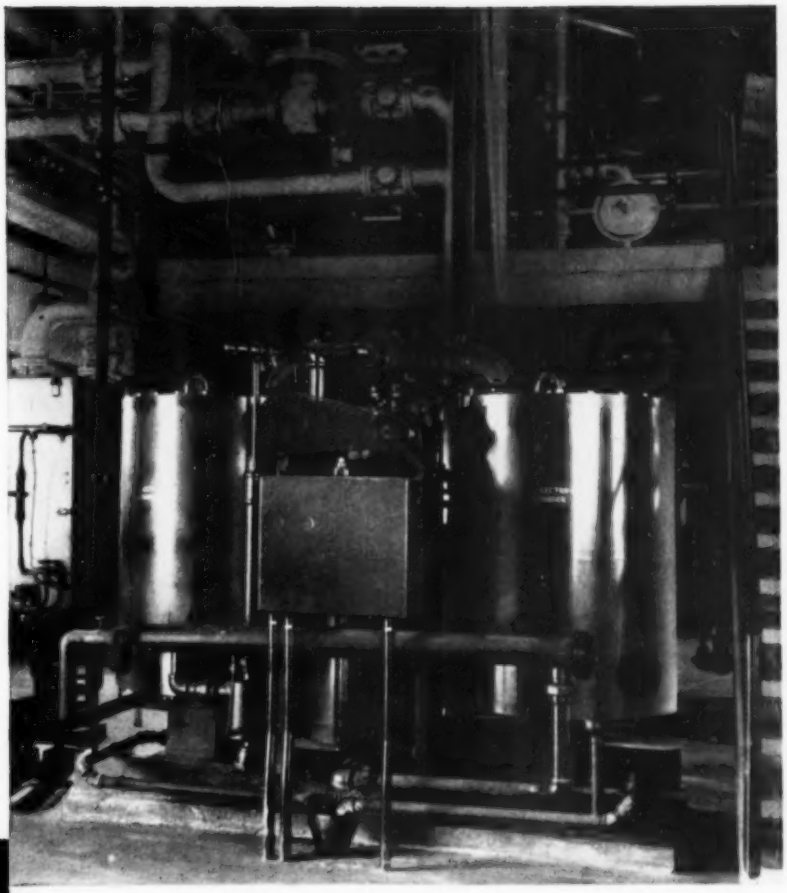
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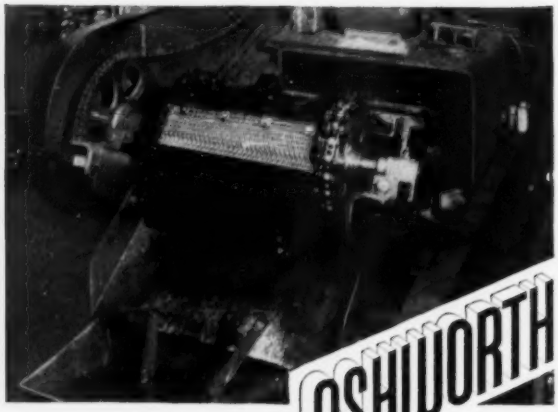
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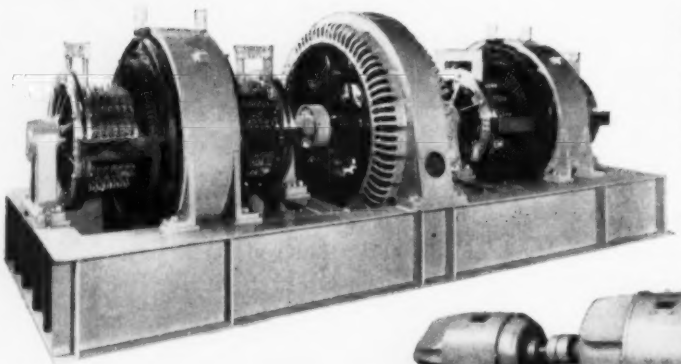
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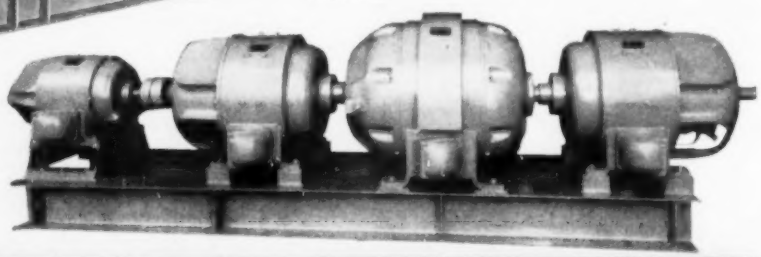
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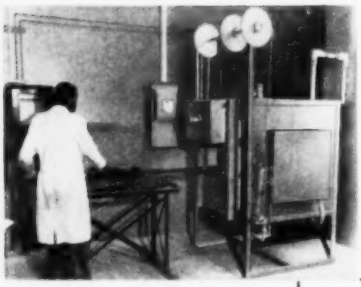
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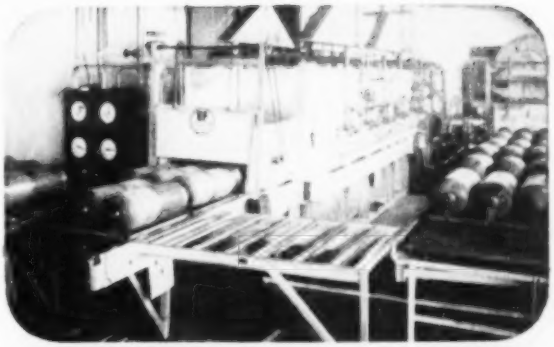
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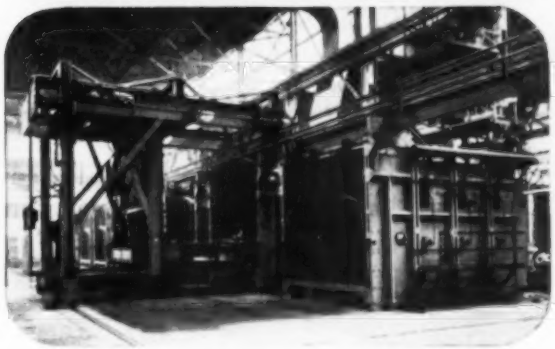
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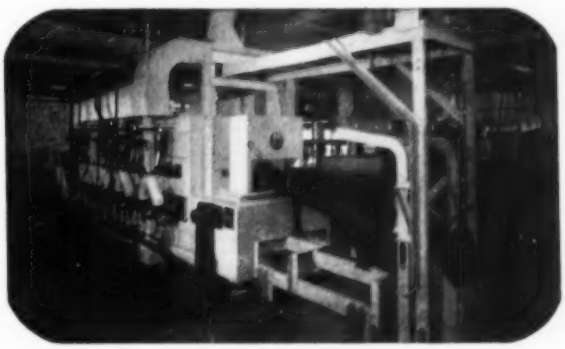
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